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Operationally Responsive Tasking

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THESIS

OPERATIONALLY RESPONSIVE TASKING

by

Aaron C. Bass

September 2011

Thesis Advisor: Alan D. Scott
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OPERATIONALLY RESPONSIVE TASKING

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ABSTRACT

This paper presents evidence that the United States military and intelligence communities have a history of focusing on hardware while neglecting the need to examine processes. It proceeds to illustrate that current ORS initiatives appear to be doing the same. A case study is presented highlighting the ramifications of neglecting processes when trying to improve operations. ISR tasking is examined, including the potential that politics exerts influences upon the process. The concept of Operationally Responsive Tasking is presented, not as a specific methodology for tasking satellites, but as a generalized model offering insight into the ramifications of certain tasking process design decisions. Specific constructs introduced include Tasking Depth, Tasking Breadth, Petitioner Tasking, and Supplicant Tasking. The model is shown to offer insight into tasking process modifications and their impacts. The potential for the Virtual Mission Operations Center software to implement the ability to modify a tasking process on-demand is discussed. VMOC is shown to be a sound platform for implementing the basic concepts of ORT, including reducing the expertise required to utilize ISR satellites through the use of ontologies. Responsiveness is shown to be a limited resource that is tied to the capacity of collection assets. Specific recommendations for further research into mathematical models to guide tasking process decisions are offered.

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LIST OF ACRONYMS AND ABBREVIATIONS

COCOM   Combatant Commander

DoD   Department of Defense

GIG   Global Information Grid

ISR   Intelligence, Surveillance, and Reconnaissance

JFC   Joint Force Commander
JRP   Joint Reconnaissance Platform

ORS   Operationally Responsive Space
ORT   Operationally Responsive Tasking

VMOC   Virtual Mission Operations Center

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I.   INTRODUCTION

Operationally Responsive Space (ORS) has captured the attention of the space community. Several ORS satellites have been launched, the ORS Office has been created, and a plethora of articles and papers have been written. A search through articles dealing with ORS reveals that the preponderance of them focus upon hardware, its associated software, or the process for acquiring them. What appears to be conspicuously absent is an attempt to better understand and improve the tasking process for current and future satellites. Such an endeavor is critical to ensure ORS can deliver increased support for the Joint Force Commander as specified in the Department of Defense (DoD) Plan for Operationally Responsive Space [1].

This paper will present evidence that this focus upon hardware, software, and acquisition without commensurate emphasis upon developing more responsive tasking processes creates an unbalanced approach. Additionally, it will touch on the potentially negative impact that politics may have on the utilization of ISR satellites. This negative impact may extend to ORS as a whole if measures are not developed to insulate the ORS community from the disruptive influences of politics. The concept of Operationally Responsive Tasking, or ORT, will be introduced and discussed. While not a specific tasking methodology, ORT seeks to present standardized ways in which tasking processes may be analyzed and compared. Specific attention is placed upon identifying privileged and disadvantaged users of a tasking process. By avoiding the development of highly specific constraints in favor of focusing upon objective measures of responsiveness, ORT may have usefulness in assessing tasking processes for multiple satellite systems in addition to ORS.

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II.   A HISTORY OF HARDWARE FIXATION

Hardware, not alternative approaches to responsiveness, has been very much the hallmark of ORS to date. Lt Col Scott Larrimore captured this issue effectively in his paper *Operationally Responsive Space: A New Paradigm or Another False Start*:

> Operationally Responsive Space has focused on a material solution to solve the perceived need to better support joint forces from space. However, this view is a bit short sighted. If needed, there are many other tactics and procedures space commanders could enact to better support tactical forces in emerging crises. [2]

This hardware fixation is not a new phenomenon. Indications that the United States has a history of focusing upon intelligence hardware, to the detriment of processing and non-hardware aspects of intelligence production, can be found in the Congressional record going back at least as far as 1996 [3]. Major Shane Hamilton captured this issue well in the following excerpt from *Balanced Insanity: An Argument for the Inclusion of Tasking, Processing, Exploitation, and Dissemination in Future Security Assistance Unmanned Aerial Vehicle Programs*.

> As the United States increasingly depends on its airborne intelligence collection systems, too much of the focus traditionally has been placed on the platforms themselves to the neglect of the supporting intelligence architecture that makes the intelligence platforms effective. [4]

The focus on hardware appears to extend beyond the ORS and intelligence communities, with indications that it is a larger DoD issue. Sheehan writes in his paper *The Military Missions and Means Framework* that certain DoD transformation initiatives:

> Focus largely on the material--the physical means needed for successful military prosecution--without adequate consideration for (or linkage to) the missions--the end actions that must be accomplished to meet objectives. [5]

These accusations transcend the notional. Specific intelligence satellite programs have been identified as having neglected the important aspects of tasking and follow-on processing. The Independent Commission on the National Imagery and Mapping Agency (predecessor of the National Geospatial-Intelligence Agency) found that the Future Imagery Architecture did not place enough resources against the issues of ensuring proper tasking [6]. The commission went further, indicting the entire Intelligence Community with the following excerpt from their report:

> The Commission validates the charge that the Intelligence Community is 'collection centric,' thinking first of developing and operating sophisticated technical collection systems such as reconnaissance satellites, and only as an afterthought preparing to properly task the systems and to process, exploit, and disseminate the collected products. [6]

Combined, these references underscore the assertion that a tendency to emphasize hardware over processes exists in the military and intelligence communities. There are strong indications that this continues within the ORS community.

A.   ORS TASKING MECHANISMS

The Virtual Mission Operations Center, or VMOC, is a web-based hardware and software system offering the capability to manage the tasking of ORS assets in a network-centric environment. It has been selected by the ORS Office as their primary payload planning, tasking, scheduling and visualization tool [7, p. 1]. Figure 1 depicts the tasking methodology for VMOC.
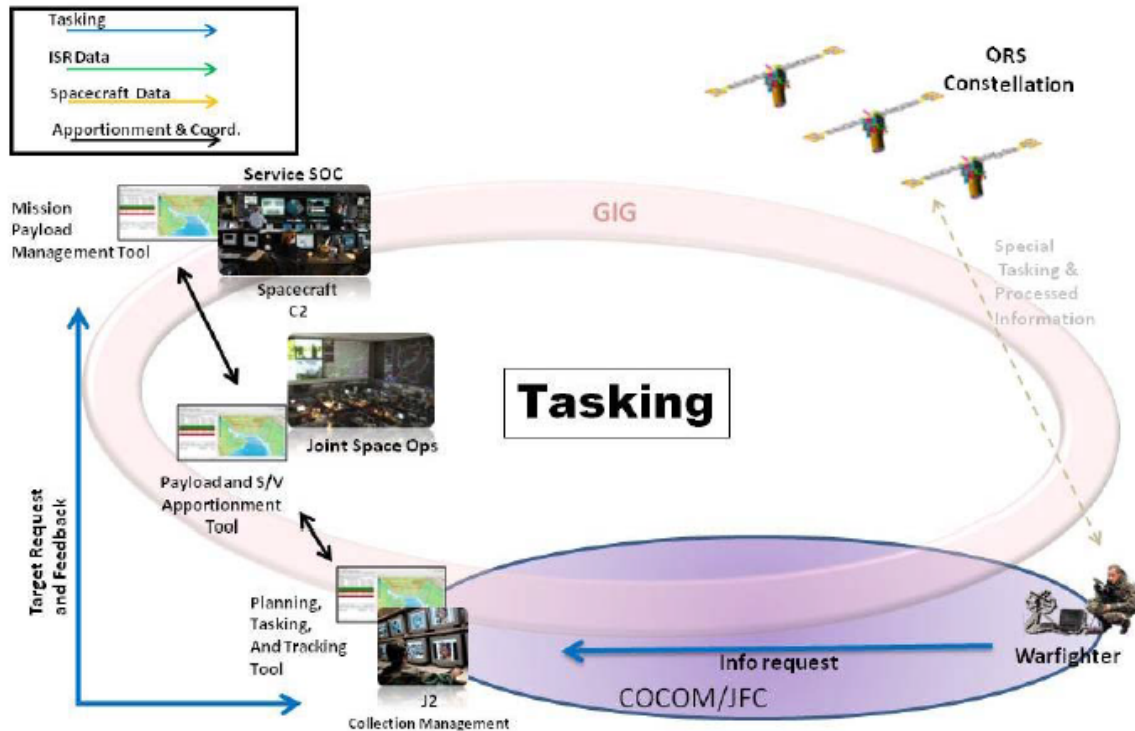
Figure 1.   VMOC Tasking Diagram (From *Virtual Mission Operations Center and ORS Ground System Enterprise* [8])

The diagram identifies generalized pathways for information. An information request flows from the warfighter where it is passed through several offices making use of software tools for tasking, apportionment, and payload management. Residing behind everything is a reference to the GIG, or Global Information Grid. Finally, an ORS constellation is depicted. This diagram focuses heavily upon the hardware and infrastructure of the ORS tasking process, but the processes utilized by the COCOM/JFC to manage information requests from the warfighter remain undefined and apparently untouched.

VMOC provides the necessary tools and communications to allow ORS assets to be tasked with few, if any, changes to current processes. VMOC has been envisioned as receiving tasking in a fashion similar to other JFC assets such as a U-2 or Rivet Joint aircraft. It includes functionality to interface directly with existing tasking tools [8] at the JFC level. This level of integration allows ORS assets to be plugged into existing processes and treated as just another

collection asset. Such integration obviously required much attention to hardware, software, and infrastructure. It also suggests that existing processes for managing warfighter requests for support were left largely intact [8, 9].

The introduction of hardware and software into an existing process will inevitably require some changes to process. Such changes are reactive in nature and may or may not improve overall operations. This paper will focus upon proactive process changes engineered to have a direct impact upon overall performance, rather than process changes designed to accommodate the introduction of hardware, software, and infrastructure modifications. The ORS tasking processes appear to be largely driven by hardware and software innovation. Little direct work has been accomplished on development of tasking models focused upon improving responsiveness for lower echelon units. ORS is continuing the tradition of improving hardware and infrastructure while largely ignoring process improvements. As will be shown, such a course can undermine or nullify efforts to improve operations.

B. CASE STUDY: ST. JOSEPH'S HOSPITAL EMERGENCY DEPARTMENT

It appears that the United States has a long history of being enamored with technology and partially neglectful of the processes necessary to ensure that technology is used properly. This history of focusing on collection technology and hardware appears to be continuing within the ORS community. The question that must be asked is, "Does this pose a problem for the success of ORS?" Unfortunately, the answer to this question is not entirely clear without an actual example of how one needs to consider processes, not just hardware and infrastructure. Within the space and intelligence communities, there are few if any unclassified examples available for examination. To find an example, we will turn to emergency medicine. There is a growing realization that overcrowding in emergency departments, which has traditionally been addressed through infrastructure upgrades, may best be addressed by modifying core processes [10]. The lessons learned by a hospital emergency department in Maryland may

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hold relevance in a discussion of the potential pitfalls of the current ORS hardware emphasis. This particular emergency department specifically focused upon solving a performance and responsiveness problem using upgrades to hardware and infrastructure rather than process improvements.

The St. Joseph Hospital Emergency Department was dissatisfied with their patient throughput metrics, an important gauge of their overall effectiveness and, arguably, their responsiveness [11]. Given the age and state of their facilities, which had 20 beds, it was determined that an infrastructure upgrade that included doubling their available beds would solve the problem. The upgrade was authorized. After the facility had been completely renovated into a state-of-the-art, much larger center with 40 beds, the department personnel expected to see improvement in their throughput. The exact opposite happened. They saw no improvement. Worse, only months after the upgrade, their performance metrics reached all-time lows [11, p. 1].

The emergency department at St. Joseph's was forced to look at other options to improve their performance metrics. Clearly, their attempt to solve issues using material upgrades had no effect, so they turned to their processes. In particular, they looked at one of their most entrenched and unquestioned processes: triage. Triage, in its simplest sense, is a prioritization process [12] which logically flows into and complements tasking processes. In emergency medicine, patients are subjected to triage (prioritization), and then the available resources are allocated (tasked) to those patients based upon the assigned priority. The resources may include such things as beds and on-duty physicians [11].

As they examined their triage processes, they found that inadequacies and rigidity in the application of the triage system could be at the root of their performance/responsiveness issues. Due to the established nature of emergency triage within the medical community, this concept was met with resistance by the emergency department staff. The staff had been trained in triage for their entire careers. They viewed the recommendations for change to the triage methodology

as a radical approach. Artful and carefully planned presentations, including a retreat for key members of the emergency department staff, were required to win buy-in for the new procedures [11, p. 3]. Once fully implemented, the new processes yielded significant improvements in the performance and responsiveness of the emergency department. Several months after the implementation of the new processes, their key metrics had improved dramatically [11, p. 5].

The experience at St. Joseph's Emergency Department has several potentially useful lessons for the ORS community. First, material solutions to performance issues may not necessarily yield the desired improvements in performance. This can be seen from the fact that, while St. Joseph's upgraded their facilities and doubled their available beds, their performance in patient throughput did not improve. The upgrades increased their patient throughput potential, but their process issues prevented them from performing to that potential. Second, process improvements are key to utilizing all of the potential offered by hardware and infrastructure. Improvements to processes may account for a significant boost in performance. St. Joseph's decision to significantly alter their triage procedures resulted in major improvements for their ability to serve more customers with the same resources. Process improvements, however, cannot deliver performance in excess of the capacity of hardware and infrastructure. Third, process change initiatives may be met with community resistance and must be carefully crafted and presented in order for that community to agree to the change. In the case of St. Joseph's, management personnel carefully targeted the supervisors with their plans so that the process changes would be adopted [11].

St. Joseph's experience shows that process changes may in some instances be more effective in improving performance than infrastructure and hardware changes. The commonality between emergency medicine and satellite-based intelligence collection lies in their efforts to accomplish a mission with potentially limited resources [13], [14]. The use of triage, the practice of allocating

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limited resources to best effect using a prioritization process [15], is a logical approach when striving to accomplish a resource-intensive mission. A tasking system for ORS satellites must also use a logical approach when it strives to accomplish its mission. At the basic level, there is commonality between ORS and emergency medicine and one can apply the lessons learned from the case study. As we look further into tasking processes, we will find that military commanders believe the authority to directly task satellites can offer them control over ISR asset usage and help to address their concerns about receipt of required intelligence.

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III. ISR TASKING

One impetus for looking at the issue of tasking is the perceived desire of combat commanders to exercise tasking authority over ISR assets. This desire appears to be shared by commanders at all levels. Army Lieutenant General Kevin T. Campbell puts forth some very interesting points of view in his article *The Warfighter's Perspective on Space Support* [16]. He wastes no time in pointing out that space support does not reach the "lower echelon units--those closest to the fight." He goes on to define the three attributes needed in warfighter-supporting space units: assuredness, persistence, and responsiveness. He defines assuredness as the receipt of the products and services needed. Persistence is summed up as continual availability of assets when needed. Responsiveness is defined as "the ability to task an asset in real time for rapid delivery of information to the troops in contact [16, p. 5]." This direct reference to tasking as a cornerstone of responsiveness reveals his recognition of the power inherent in the authority to task satellites. Given the power of tasking authority, it is important to assess the appropriate level at which that authority should be exercised. Identifying the actual processes for controlling ISR assets is difficult for outsiders due to a lack of easy insight into satellite tasking.

A. SATELLITE TRIAGE

The specific tasking processes for ISR satellites are largely cloaked in secrecy. There is scant information available in open media or unclassified documents to illuminate the established processes that are applied to make decisions about how to task ISR satellites. What we do know is that demand for ISR products outstrips the available capacity [14]. Under such a constraint, it is safe to assume that the processes in place must include decisions about which requests for support out-prioritize others. Such an assessment logically leads to a decision about which requests are actually assigned to satellites, making it a form of triage. While triage is consistently viewed as a process that is medical in

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nature, the term itself applies to any situation in which a person or organization must manage limited resources and apply them for best effect in the face of a situation where demand outstrips supply [15]. A search of literature will show that triage is used in varied fields including the mortgage industry [17], software development [18], and water resource management [15].

It is in the application of triage to medicine that we can find the most parallels to the problems of managing space assets. The simplest form of medical triage is discussed in the literature as a basic three-level prioritization that includes assessing each patient on a scale that designates their likelihood of recovery: those who will likely recover regardless of medical treatment, those who will die regardless of medical treatment, and those who will recover only with immediate medical treatment [19]. Variations on this basic process have been developed over the years, including greater numbers of priorities (5 or 7) and other improvements [19], but the general idea remains.

The process is focused upon managing a demand for services that outstrips the supply of those services, much like the situation with ISR satellites. The typical application of such a system is to take a request for service and assign it to a service provider based upon a priority. If we consider the application of this system to ORS, we can assume that a military customer might have their request for support assigned to a satellite, but only after the request is passed through a system for prioritization and approval. We will call this form of tasking Reactive Tasking, since no action occurs until a request arrives, receives a priority, and merits action based upon that priority. Conversely, we can envision a tasking system in which a need for resources is anticipated, and a satellite is assigned to a customer to be ready for use when the customer identifies a task for the satellite. We will call this Proactive Tasking.

In proactive tasking, the satellite will be as responsive as possible to the assigned unit, within its design and orbital limits. This approach carries a risk that the customer will not actually require the satellite, which has now been removed from the service of other potential customers. Such a method of managing

collection assets runs counter to established intelligence community practice, which loathes any loss of collection capability. The intelligence community takes very seriously the need to ensure that collection opportunities are not wasted. This is accomplished by running all requests for information through an extensive process that compares recent collection against currently available information [20], [4, p. 57]. The idea is to avoid committing collection assets to obtain information that is already available. A reasonable exception to this approach involves a commander who wants to know what is happening right now, for which previous collection will be of little use. Committing an asset would be the only way to obtain the information. It is in such situations that granting tasking authority to a lower echelon unit makes sense. The need for immediate information indicates that it is time sensitive and should be pursued without delay. It is in the anticipation of such instances that Proactive Tasking should be considered. Proactive tasking is the better model for satisfying Lieutenant General Campbell's definition of responsiveness, as once a satellite is assigned to a unit it will be available for tasking without potential interference from other units who might be competing for the use of the asset. Problems may arise when using proactive tasking. One of these is the need for expertise at the unit, which has received the authority to task the asset proactively.

B.   THE NEED FOR EXPERTISE

The Joint Reconnaissance Platform (JRP) experiment highlighted the potential pitfalls of using proactive tasking, specifically by delegating tasking authority over a space asset to a combatant command. In this experiment, an operational space capability was proactively tasked to a combatant commander, to be available for the specific uses determined by that commander. Among the lessons learned from the JRP experiment was that theater collection managers were unable to immediately begin tasking to full effect, thus delaying JRP's ability to fully support the warfighter [21]. The tasking learning curve for the JRP asset

was unexpectedly steep. These learning curve problems highlight the need to ensure that ORS tasking processes and methodologies are carefully considered prior to delivering a capability.

For any tasking to be effective, those charged with tasking the asset must be armed with the knowledge and understanding necessary to be able to properly utilize the asset. The greater the gap between the knowledge level of those tasking the asset and the requisite knowledge level to properly task the asset, the lower the likelihood that the asset will be properly utilized and capable of providing valuable information. Successful tasking involves closing this gap. While this gap remains open, it may serve to support the position of those who would rather keep current tasking processes in place rather than seek innovative ways in which the tasking process might be improved.

C.   RESISTANCE TO CHANGE

The suggestion that the goals of ORS may be advanced by reassessing the existing processes for tasking ISR satellites unavoidably indicts the current tasking processes. Such an indictment flies in the face of the apparently established view that the current tasking system is the desired methodology for tasking ORS assets. Deputy Undersecretary of Defense Thomas Behling directed that the tasking for the sensors carried on TacSat-2 "must come from established intelligence community mechanisms [2, p. 40]." This can easily be read as a wholesale endorsement of the current tasking process. Experimentation is essential to developing operational and responsiveness efficiencies for ORS. Constraining the tasking system to established processes limits the potential for a developmental initiative such as ORS. Mr. Behling arguably crushed any opportunity for innovative thinking with respect to tasking methodologies for TacSat-2. There is little unclassified information available to explain the logic behind such an edict, but one possibility is that politics played a role.

D.   POLITICAL PRESSURE ON ISR SATELLITE TASKING

Given the Presidentially ordered requirement that U.S. intelligence assets serve multiple portions of the government besides the military [22], it is highly likely that politics may be a prime force in the tasking of assets. Take as an example another issue with TACSAT-2, which was launched in 2006 carrying multiple payloads including an imaging sensor [23] and a device for intercepting communications [23], [24]. Several months after launch, those payloads had not been turned on. While the specifics are shrouded in secrecy, what is apparent is that there was a political and bureaucratic battle over the ownership of the mission of collecting intelligence, and the ownership of the data [25]. If political considerations can keep an entire payload on an ORS asset from even being activated, it seems no stretch that the same forces might easily exert influence over the tasking of those same assets. This is unlikely to please military commanders who believe they are not getting the support they require.

Besides the perceived power contained in the ability to control the tasking of satellites, another explanation for the emphasis placed by the warfighter on the ability to directly task satellites may lie in the fact that the current overall ISR satellite infrastructure was not built to be military-specific. Cebrowski and Raymond argue in *Operationally Responsive Space: A New Defense Business Model*, that current ISR space assets are not designed for military use. They refer to the need to "tease" military utility from satellites that were designed with strategic needs in mind [26]. A look at *Executive Order 12333, United States Intelligence Activities*, clearly specifies in paragraph 1.1 that intelligence gathering activities of the U.S. government:

> Shall provide the President, the National Security Council, and the Homeland Security Council with the necessary information upon which to base decisions concerning the development and conduct of foreign, defense, and economic policies and the protection of United States national interests from foreign security threats. [22]

The fact that intelligence gathering activities must service much more than military customers creates an unavoidable climate of competition for resources,

especially given the fact that resources are limited. This built-in tension was predicted by congress as far back as 1997 when the Intelligence Authorization Act report from the House of Representatives noted that:

> Competition for collection resources, in particular between immediate military requirements and longer-term national interests, is going to become increasingly fierce. [3]

This is further indication that politics may play a central role in the tasking of overhead ISR assets. For military commanders at all levels, including the lowest echelon tactical units, the need to fight for their ISR satellite support in addition to fighting their adversary on the battlefield takes energy and resources away from their primary mission. It may also explain why Lieutenant General Campbell speaks of the Army looking to alternatives to satellites, which might be more easily controlled and tasked by the front-line commander [16].

E.   CONTROL OF ISR SATELLITE TASKING

Authority over ISR satellite tasking must be carefully placed. We have already determined that expertise is required to properly task an asset while taking into account the overall operational plan [27]. Such expertise and awareness are not likely to exist in small forward units. The JRP experiment found that experienced collection managers had difficulties integrating the platform into their operations, casting significant doubt upon the ability of minimally trained personnel to manage the tasking of satellites. Given this precedent, ORS would appear to be a poor choice for delivering sensors that can easily and effectively be directly tasked by very low-level units. This can be directly attributed to the likelihood of a large gap between knowledge levels at those units and the knowledge levels required to manage ISR satellites. If the desire is to allow such low-level units to exercise tasking authority on ORS assets, this knowledge gap must be decreased.

Two options should be considered. The less risky, but potentially more difficult and expensive option, involves ensuring all low-level units that might be

granted the opportunity to task satellites have personnel with the requisite knowledge for the job. An alternative option involves lowering the knowledge level required to task satellites successfully. By lowering the requisite knowledge level, more units may be capable of exercising tasking authority on ORS assets. In later chapters, this paper will discuss a tool that may be able to effectively lower the knowledge level and enable tasking authority to reside at lower levels. Despite the stated desire of commanders to directly control tasking of ISR assets, there is ample evidence that under current conditions this is neither practical nor effective. What is needed is a change in the overall approach to tasking of ISR satellites.

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IV. OPERATIONALLY RESPONSIVE TASKING

Operationally Responsive Tasking, or ORT, offers alternative ways to approach the problem of delivering responsiveness to military commanders. The concept of operationally responsive tasking does not define the ideal arrangement for tasking. Instead, it attempts to define some measures of responsiveness. These measures can be used to objectively assess the responsiveness of current or envisioned tasking systems. By defining basic measures of responsiveness, satellite operators and customers will have tools to aid them in assessing the overall responsiveness of a given tasking methodology. A key aspect of this is identifying customers who may be disadvantaged or overly privileged with respect to their ability to receive support. Several basic issues have been identified that may impact or enhance the ability of customers to receive their needed support. In addition to the concepts of Reactive Tasking and Proactive Tasking, the concepts of Tasking by Petition and Supplicant Tasking are introduced. They each carry unique implications for the responsiveness of a tasking system, and are designed to allow observers or planners better insight into the implications of various tasking methodologies.

A. TASKING BY PETITION

Tasking by Petition offers a simple model to approach the problem of managing collection on behalf of multiple agents using limited resources. This is a reasonable representation of the current intelligence community situation: There are numerous federal agencies or departments that require the services of collection platforms [22], and the desire for intelligence services often outstrip the available resources [14]. In order to assess the responsiveness of a tasking methodology, one option is to model it as Tasking by Petition. The general arrangement of organizations in Tasking by Petition involves a largely vertical relationship, with the collection asset located at the top, and the various entities

involved in the process occupying successively lower levels beneath the collection asset. Potential tasking flows from lower levels to higher levels, allowing the system to be characterized as a Tasking Ladder.

Tasking by Petition includes several main players, including petitioners, gatekeepers, a tasking authority, technical execution agents, and the collection assets. Petitioners include any organization that is authorized to request intelligence information collection. There may be few or many petitioners, depending upon the policies set forth by parent organizations. Petitioners may be thought of as the reason for collecting intelligence and also the consumers of finished intelligence.

1.   Gatekeepers

In the Tasking by Petition model, gatekeepers define rungs in the tasking ladder. Their function is to exercise triage on the tasking requests that are received from the next lower level on the tasking ladder. The requests are prioritized, and based upon the assigned priorities some are passed up to the next higher rung on the tasking ladder, where they may again be subjected to a triage process. Each level may have triage rules that are specific to that level, so a request may receive a high priority at several successive levels, only to face different rules at the next higher level and receive a low priority. In such an instance, the request may not be passed up to the next higher level in spite of high priority at lower levels.

Without gatekeepers, the amount of tasking requests that would be sent to the technical execution agents, who exercise direct control of the collection assets, would be potentially overwhelming and force them into the role of gatekeeper, which is not the intent in this model. Depending on the overall tasking methodology, there may be few gatekeepers or many. It is noteworthy that different petitioners may have different numbers of gatekeepers between them and the technical execution agents. This would potentially make it more or

less difficult for them to get a tasking request into the queue for execution versus other petitioners. As we will see, this can serve as a valuable measure of responsiveness.

2. Tasking Authority

The Tasking Authority wields the authority to establish the utilization of an ISR asset and is the final gatekeeper in the system. The Tasking Authority has the final say on which taskings are elevated to the technical execution agents for actual execution on the asset. There may or may not be lower-level gatekeepers as well, whose purpose is to prioritize and filter requests from lower levels up towards the Tasking Authority. Technical Execution Agents occupy the next higher rung on the tasking ladder and maintain responsibility for exercising direct control over the collection assets. For ORS, these agents would likely be the satellite payload controllers who are responsible for sending commands and monitoring the performance of the payload. The collection asset occupies the top spot in the tasking ladder, as the final recipient of tasking. The collection asset, technical execution agent, tasking authority, gatekeepers, and petitioners all play unique parts in the overall model. Particularly important when assessing responsiveness are the relative positioning and numbers of the petitioners, gatekeepers, and tasking authority.

B. TASKING DEPTH

The petitioner-tasking model can be used to evaluate tasking processes that utilize triage at one or more levels. The first step to analyzing a tasking process is to identify the participants and place them into a diagram depicting their respective positions and roles. Figure 2 shows a very basic arrangement that reflects a simple tasking ladder.
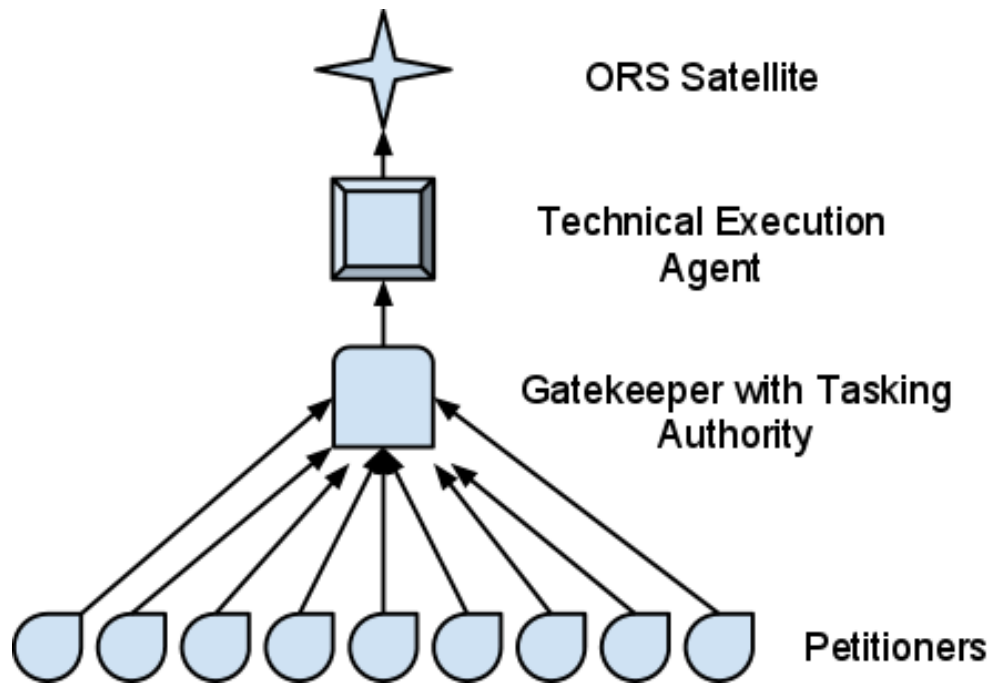
Figure 2.   Diagram of a Basic Petitioner Tasking Model

Petitioners are located at the bottom of this diagram and may be categorized by several methods. One method is to categorize them based upon the number of gatekeepers, including the Tasking Authority, between a petitioner and the Technical Execution Agents. We can refer to this number as the tasking depth associated with a given petitioner or group of petitioners. In Figure 2, there is only one gatekeeper between the petitioners and the satellite, giving this model a tasking depth of one. All of the petitioners reside at a tasking depth of one, but as we shall see, it is possible to have multiple levels with petitioners located at various levels. Tasking depth may vary from zero to n, depending on the number of gatekeepers in the model. Figure 3 displays a slightly more complicated situation with a total tasking depth of 2.
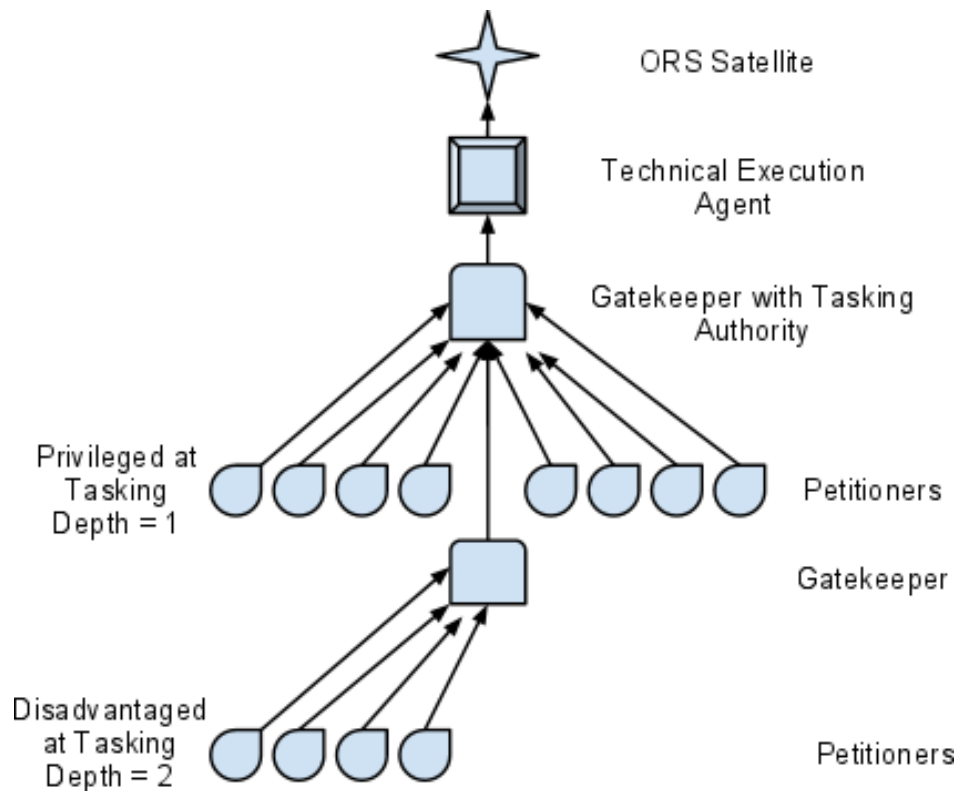
Figure 3.   Diagram of a Petitioner Tasking Model Illustrating Tasking Depth

Tasking depth is a useful measure of the difficulty individual petitioners will have influencing the utilization of the satellite. The greater the number of gatekeepers between petitioner and technical execution agent, the less influence the petitioner is likely to have upon the actual use of the collection asset. This will give some insight into the responsiveness of the system for individual petitioners. The greater the tasking depth of a petitioner, the lower is the likelihood that the system will be responsive to that petitioner. By comparing the tasking depth of various petitioners and categorizing them based upon their tasking depth, we can identify potentially disadvantaged and privileged petitioners.

Petitioners can be categorized in other ways as well, offering a better understanding of the community that seeks access to ISR assets. Such options for categorization may include, but need not be limited to, organizational level, combat capability, geographic area of operations, and type of unit. Such categorizations can make possible an analysis of the usage of ORS assets.

Additionally, it can offer the possibility of analyzing the types of units that are making requests for ORS ISR support, offering insight into which units may be otherwise ISR disadvantaged. Beyond understanding the demographics of units requesting and receiving ORS support, categorizing units can be very important when attempting to focus ORS support. By identifying units that fall into discrete categories, those units can be specifically targeted for support from ORS. This paper will discuss specific ways in which ORT can be used to focus such support.

C.   TASKING BREADTH

In the effort to avoid excessive tasking depth, and its associated negative impact on responsiveness, it might seem advisable to decrease the number of tasking levels in the effort to limit tasking depth. If applied carefully, this method may serve to mitigate the negative impact of excessive tasking depth, but it carries some risks to responsiveness if not carefully executed. Assuming the same number of units (petitioners) are to be served, decreasing the number of levels will require concentration of petitioners upon fewer levels. Managing these more densely populated levels to maximize responsiveness may require multiple gatekeepers per level, or a greater concentration of petitioners per gatekeeper. In a diagram of this situation as seen in Figure 4, it becomes obvious why this is dubbed Tasking Breadth.
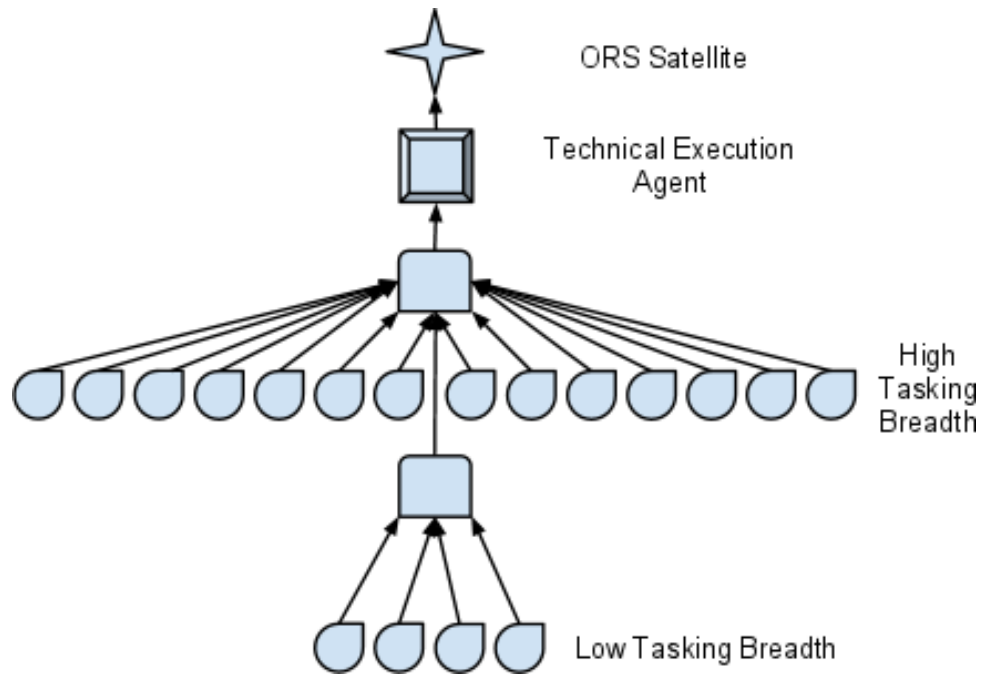
Figure 4.   Illustration of High Versus Low Tasking Breadth

1.   Tasking Breadth Tradeoffs

In the diagram, the higher level clearly has a greater tasking breadth, while the lower level exhibits a low tasking breadth. The implications of tasking breadth on responsiveness become clear when we set up a comparison between two different ways to provide service to the same number of petitioners. A close examination of a simplified situation in which we seek to build a tasking ladder containing 50 petitioners shows how decreasing the overall tasking depth at the expense of tasking breadth can offer improvements up to a point. We will assume that the initial ladder has a tasking depth of 5, with ten petitioners at each level. The expected pass-through rate of each gatekeeper will be assumed to be only one task to maintain simplicity. Figure 5 depicts the structure and specifies the tasking depths.
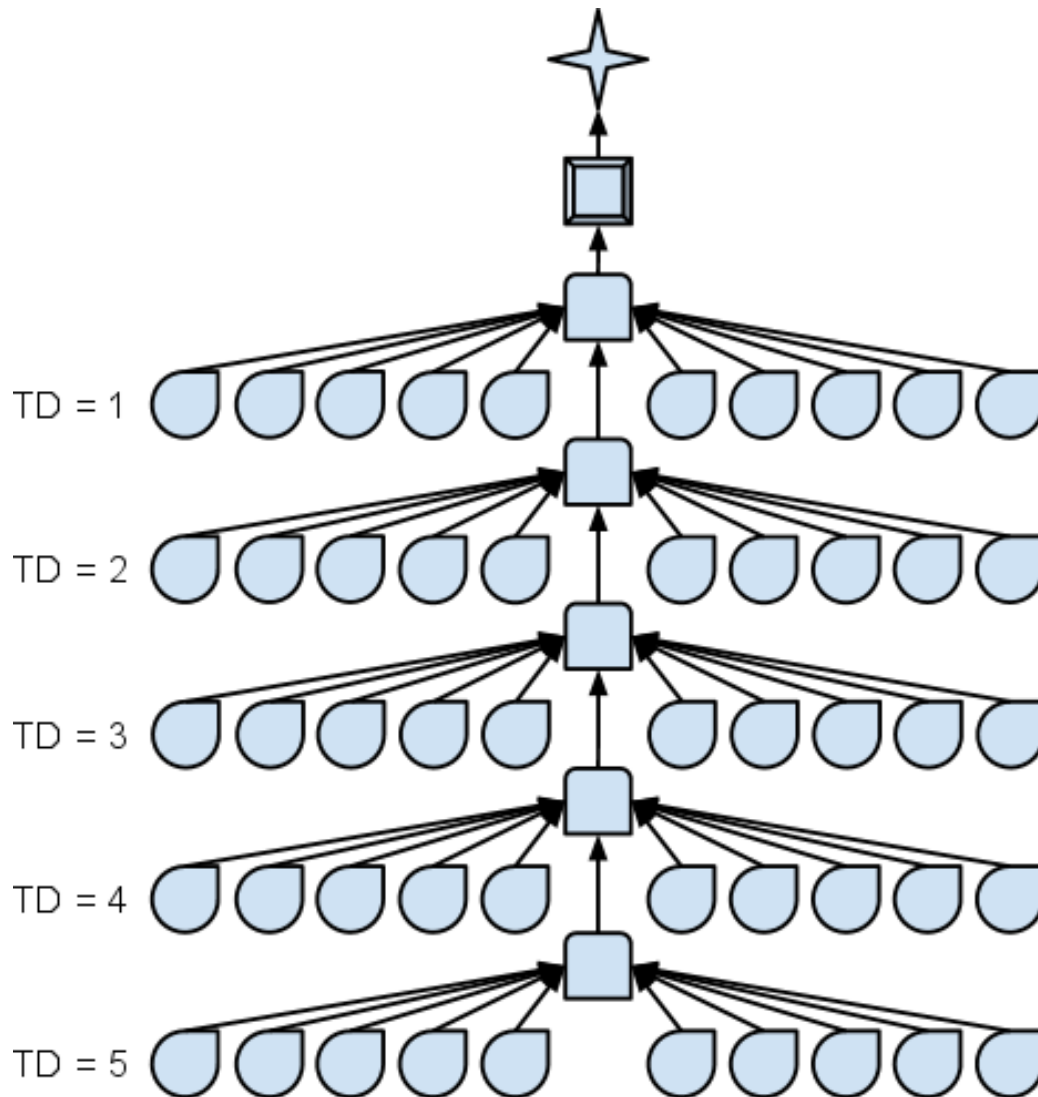
Figure 5.   Notional Tasking Structure with 50 Petitioners with a Maximum Tasking Depth of 5

The lowest level will have a 1/10 pass-through, while all higher levels will have a 1/11 pass-through. We can calculate the overall odds of having a task make it to execution for each level as shown in Figure 6.
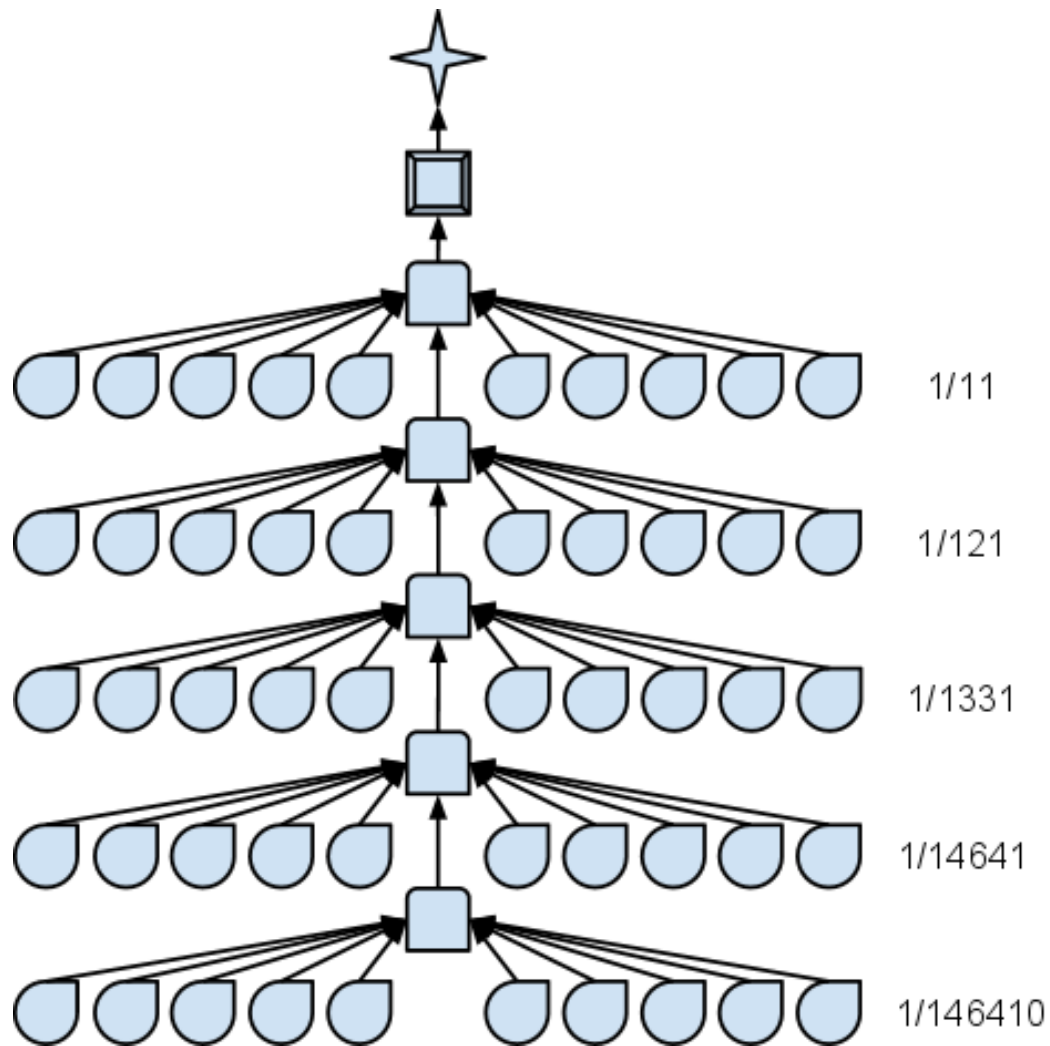
Figure 6.   Depiction of Likelihood of Receiving Tasking Based Upon Tasking Depth

It becomes apparent that increased tasking depth can quickly render units in the lower levels highly disadvantaged. In the notional situation above, units at a tasking depth of 1 are 13,310 times as likely as units at tasking depth 5 to receive tasking. This clearly places those units at the bottom of the tasking ladder in a severely disadvantaged position. One potential tactic to address this situation is to reduce the tasking depth. Keeping the original 50 petitioners in the model requires an increase in tasking breadth. If we limit the tasking depth to 2

and evenly divide the 50 petitioners between them, we end up with a tasking breadth of 25 petitioners per level. This situation has dramatic impact upon the likelihood of petitioners receiving tasking as shown in Figure 7.
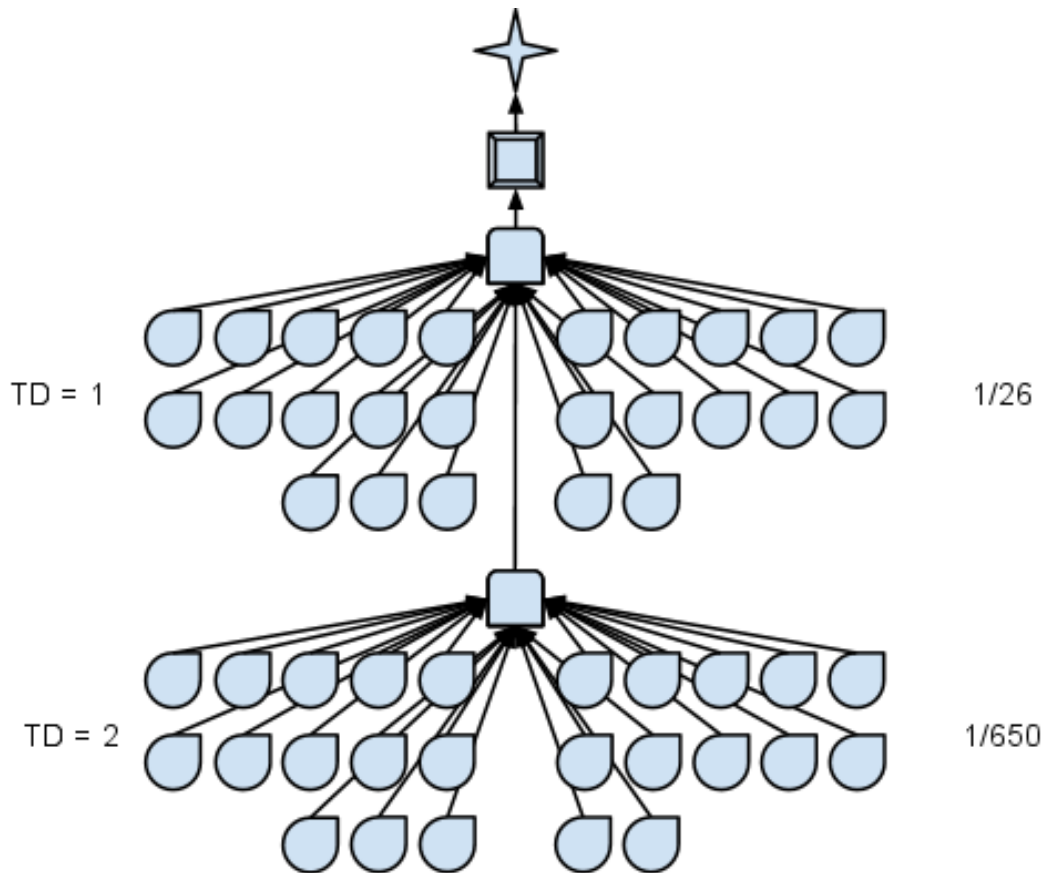
Figure 7.   Modified Tasking Structure with 50 Petitioners and Maximum Tasking Depth of 2; Odds of Task Satisfaction Included on Right

2.   Impact of Modifying Tasking Breadth

Increasing tasking breadth while decreasing tasking depth can be shown to greatly reduce the disparity in the odds of task satisfaction for the various petitioners. The worst-case odds of satisfaction went from 1 in 146,410 to a much larger 1 in 650. In this situation, the petitioners at a tasking depth of 1 are 25 times more likely to receive tasking than those on the lowest level, a great improvement over the previous situation. If all petitioners were moved to a single level where tasking depth is one, then the overall odds reduce further to 1 in 50.

The downfall of this situation is that a single gatekeeper now has to evaluate a much larger number of requests for support, increasing overhead. Other problems arise as well. This one gatekeeper must now also find some way to manage triage amongst various missions and operational levels. This would arguably require an uncommon depth of knowledge for a higher-level organization to maintain. A third potential pitfall involves subordinate units submitting requests directly to the tasking authority, without coordination through their immediately superior units. This might lead to multiple redundant requests for collection as the units will not have insight into the requests made by their subordinate units. The single gatekeeper may shoulder the burden of resolving redundancies, which would be expected to increase workload and manning requirements. These complications potentially reduce the benefit of decreased tasking depth at the expense of increased tasking breadth.

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V.   GATEKEEPER TRIAGE RULESETS

Gatekeepers must have methods for performing triage on the requests received from petitioners. A reasonable approach involves establishing basic rules for decision-making. In the ORT model, rulesets play a vital role in the overall tasking system. The rules adopted by gatekeepers determine the priority of requests and directly impact the likelihood that they will be elevated to the next higher rung on the tasking ladder. The interaction between gatekeeper rulesets and petitioner requests can be described using set notation and Venn diagrams.

A.   DESCRIBING RULESETS

We start by defining all possible intelligence information as the Universal set, or U. Within that set, we define the subsets of information that petitioners believe are of concern for their assigned missions and for which tasking is requested. We designate another set comprised of the information that satisfies the triage ruleset adopted by the gatekeeper such that a high priority is assigned. For this discussion, we will assume one gatekeeper (G) and three petitioners (A, B, C). In the best-case scenario for responsive tasking, we find that all of the elements within sets A, B, and C are also elements in the gatekeeper's set, G. This makes them subsets of G as shown in Figure 8.

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$A \subset G \text{ and } B \subset G \text{ and } C \subset G$

The collection sets desired by the petitioners (A, B, C) satisfy the gatekeeper's triage rules (G).
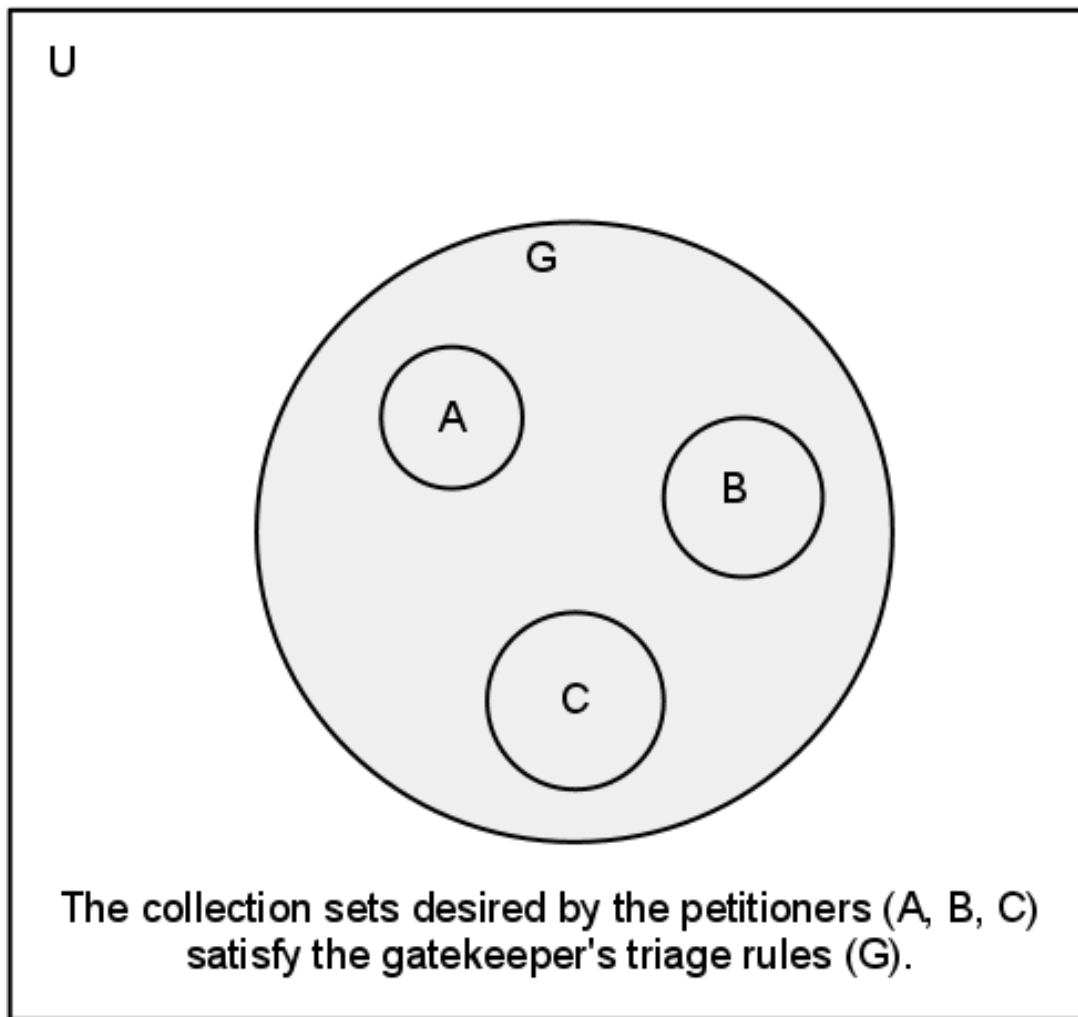
Figure 8.   Venn Diagram Illustrating Situation in which Petitioners' Desired Tasking Satisfies Gatekeeper's Triage Ruleset

This is the preferred situation for responsiveness. The set of information that satisfies the gatekeeper's triage ruleset (G) will not rule out any of the desired collection of the petitioners (A, B, C) by assigning them a low priority. A slightly less ideal situation arises when there is only partial overlap between the gatekeeper's set and the sets of the petitioners. In this case, there is an intersection between the sets as shown in Figure 9.

$$A \cap G \text{ and } B \cap G \text{ and } C \cap G$$
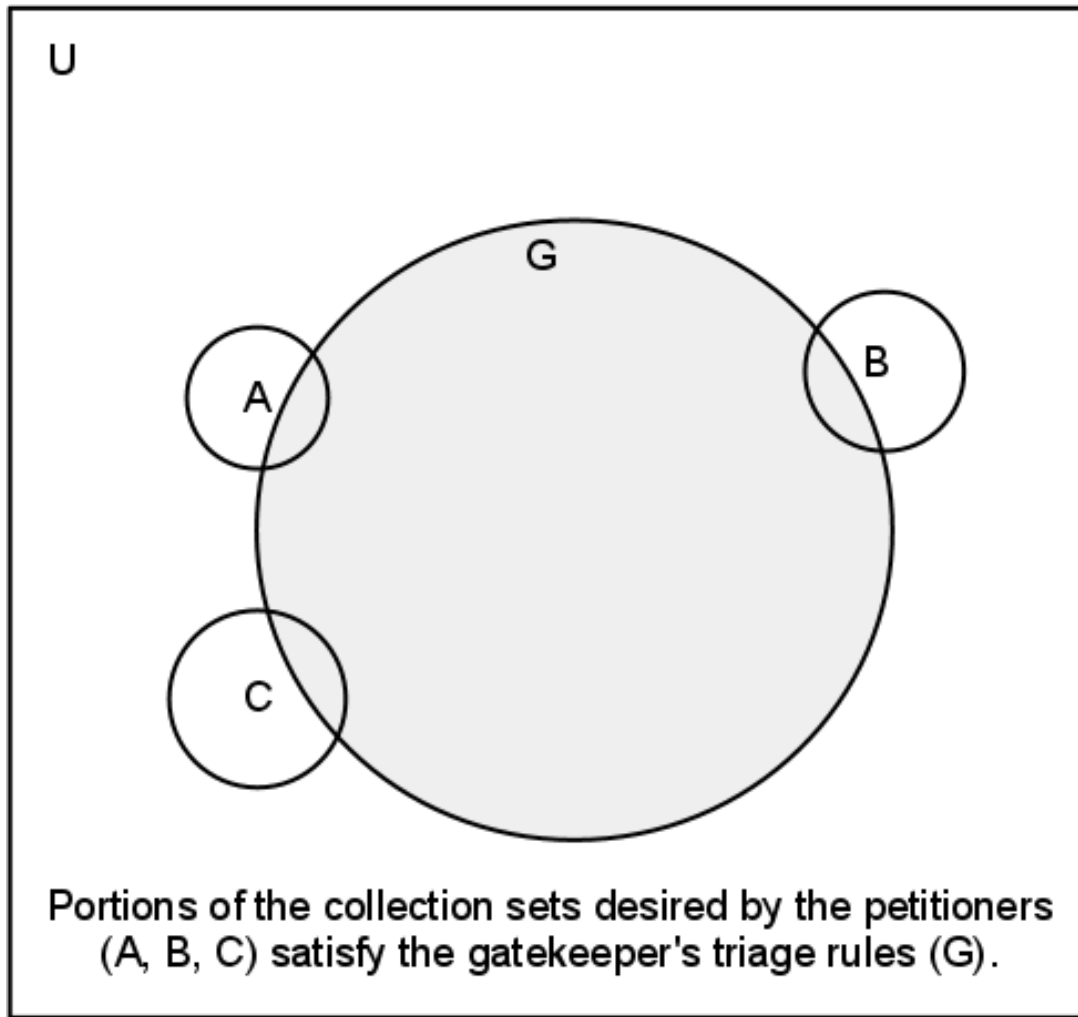
Figure 9.   Venn Diagram Depicting Situation in which Portions of Petitioners'
Tasking Satisfies Gatekeeper's Triage Ruleset.

Each of the notations above represents the elements that are shared between the gatekeeper and the petitioners. As long as the set represented by the intersection is not empty, there is commonality. For the tasking system, this indicates that at least some of the collection tasks desired by the petitioners are deemed valuable by the gatekeeper and have a chance of ultimately being tasked. One would expect that the tasks that fall outside of G will not be collected due to their failure to satisfy the triage rules established by the gatekeeper and their resulting receipt of low priority. It is possible to model an instance in which

there is no commonality between the set of acceptable collection and the desired collection sets of the petitioners. In the instance there is no commonality, the sets can be said to be disparate. Their intersection returns a null, or empty, set. Figure 10 depicts such a situation.

$$A \cap G = \{\phi\} \ and \ B \cap G = \{\phi\} \ and \ C \cap G = \{\phi\}$$

The collection sets desired by the petitioners (A, B, C) do not satisfy the gatekeeper's triage rules (G).
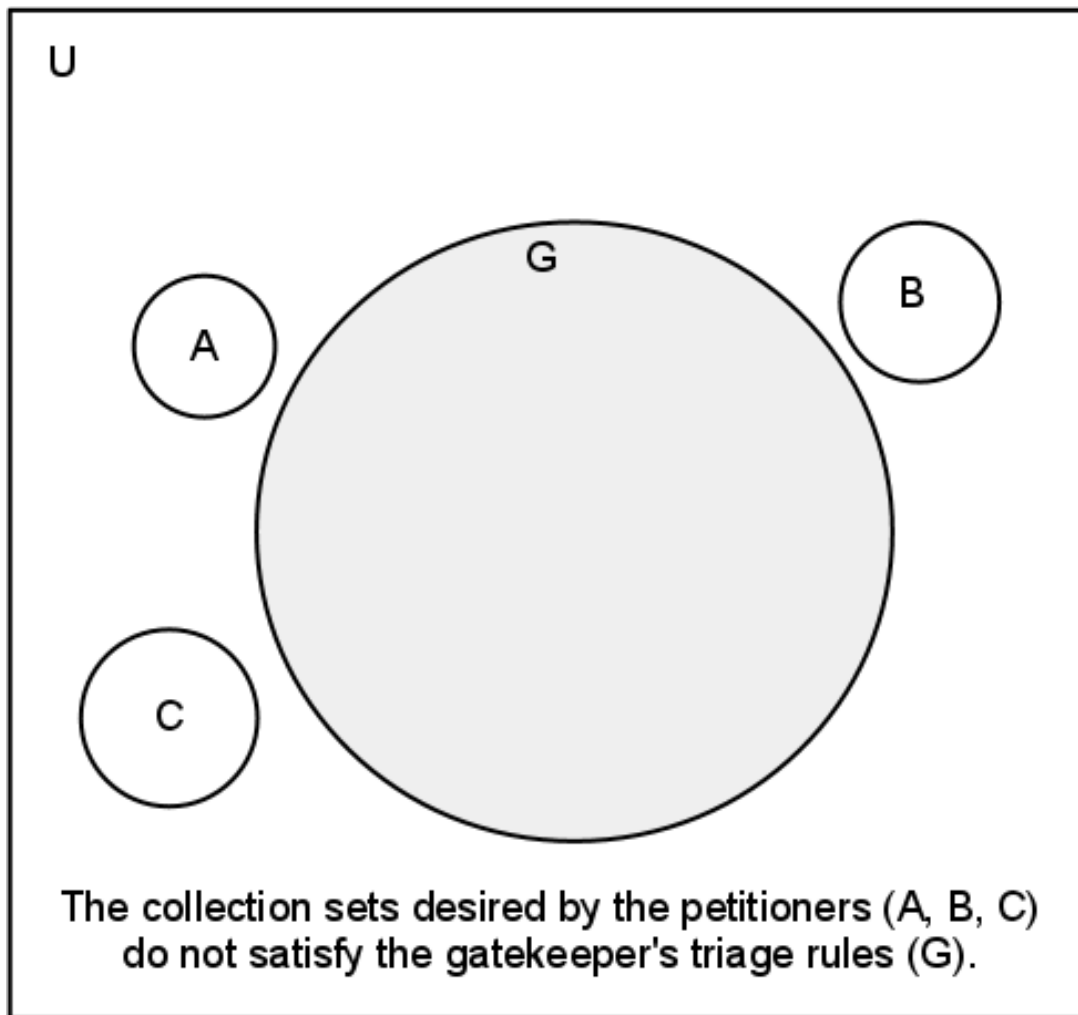
Figure 10.   Venn Diagram Depicting Situation in which Petitioners' Desired Tasking Does Not Satisfy Gatekeeper's Triage Ruleset

Where the petitioners' desired collection does not intersect the collection that satisfies the gatekeeper's ruleset, responsiveness is degraded. This is due to the fact that the gatekeeper's triage rulesets amount to impediments to the ability of the units to "task an asset in real time" as desired by Lieutenant General

Campbell. We can identify the set of collection tasks desired by the petitioners as the union of their sets of desired collection tasks.

$$A \cup B \cup C$$

This specifies all tasks that are deemed desirable by the petitioners. We can also identify all tasks that do not satisfy the triage ruleset of the gatekeeper as the complement of G.

$$\sim G$$

The intersection of these two sets identify the tasks that are desired by the petitioners but do not satisfy the ruleset of the gatekeeper.

$$\left(A \cup B \cup C \right) \cap \sim G$$

The ratio of this sum against the total tasks desired by the petitioners yields a measure of non-responsiveness in the specific rung of the tasking ladder.

$$\frac{\left(A \cup B \cup C \right) \cap \sim G}{\left(A \cup B \cup C \right)}$$

To be operationally relevant, rulesets must be dynamic. As situations change on the battlefield, rulesets must flex in response. A static ruleset might quickly become useless in light of changing situations, focusing collection assets where they are not needed and reducing their overall usefulness. It is critical that organizations maintain the ability to quickly modify rulesets in response to changing needs. When such changes are required, they directly impact the ability of lower level petitioners to successfully elevate their tasking requests for execution. This may work in favor of the petitioners. In some instances, changes to rulesets may effectively block petitioners from receiving the tasking they require.

B.   SUPPLICANT TASKING

Supplicant Tasking arises when the collection desired by a petitioner does not satisfy the triage ruleset of a gatekeeper. Supplicant Tasking represents a potential dysfunction in Petitioner Tasking that arises due to a mismatch between the mission concerns of petitioners and gatekeepers. As an example, a small

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forward unit charged with securing a remote town may need some intelligence gathered to help them understand the local tactical situation. For the unit, this information is deemed critical to their ability to maintain control of the town. When they submit a tasking request to obtain this information, it goes up to the next higher-level gatekeeper, who tests it against their triage ruleset. Based upon the ruleset, they assign a priority to the task. In the event the tasking request is assigned a very low priority, it may be rejected and the petitioner is now faced with the problem of supplicant tasking. The dilemma here is clear. The unit requires this tasking to receive the information it is expected to gather, but the established rulesets make it nearly impossible to gain the cooperation of the gatekeeper. At this point, the unit must either give up on the tasking request, or develop some method to convince the gatekeeper to accept the task. This might take the form of humbly requesting the task be approved (supplicating) or otherwise convincing the gatekeeper that their triage ruleset was not properly developed or applied. In either case, the need to engage in extended dialogue in order to receive the tasking they need degrades the responsiveness of the overall system.

Supplicant tasking may arise in a situation where a gatekeeper has limited responsibility, or no responsibility, for the mission of one or more petitioners. This lack of responsibility may be expected to influence the ruleset of the gatekeeper to the detriment of one or more petitioners. We theorize that the more removed the gatekeeper is from the petitioner on the tasking ladder, the more likely that this situation will occur. If the gatekeeper has no responsibility for the missions of any petitioners, it may have difficulty developing a coherent triage ruleset. Under such circumstances, the application of a triage system may be problematic without external guidance in the development of the ruleset. Lacking outside guidance, it is difficult to determine whose mission is more important, placing the onus for convincing the gatekeeper firmly into the lap of the petitioners. It is this

need to convince an uninvolved party of the worthiness of a particular mission and its associated collection requirements that transforms the petitioners into supplicants.

A slightly different situation arises when a gatekeeper has responsibility for only some of the missions of petitioners. In such a case, the disenfranchised petitioners are not only transformed into supplicants, they are disadvantaged supplicants relative to the other petitioners who have a mission shared with the gatekeeper. They have to convince the gatekeeper, who has a direct interest in the missions of one or more other petitioners, that they should divert those resources to a mission for which the gatekeeper has no responsibility. This is unlikely to meet with success unless the asset is underutilized or unnecessary for the success of the gatekeeper's missions.

One possibility to remedy the potential issues with Supplicant Tasking involves moving the Tasking Authority down to a level where petitioner and gatekeeper missions maintain enough similarity to drive the development of triage rulesets that benefit all petitioners. There is no guarantee that petitioners will receive their taskings, but the triage rulesets will likely not automatically disqualify their desired taskings. This approach may tend to drive tasking authority lower on the tasking ladder, decreasing tasking depth. Using this approach to identify dysfunction between petitioners and gatekeepers may help with a determination of the appropriate level at which to place tasking authority to maximize responsiveness.

To avoid Supplicant Tasking, the mission responsibilities for various levels must be carefully examined to ensure that they are at least partially reliant on petitioners beneath them in the tasking ladder. Since this approach may indicate a need to move the Tasking Authority down the ladder, it also has the benefit of decreasing the Tasking Depth, which should also increase the efficiency and responsiveness of the overall tasking system. The exception to this is for higher level petitioners who are cut off from the ability to task the asset as the Tasking Authority moves to levels beneath them on the tasking ladder as depicted in

Figure 11. An extreme example of this might include moving tasking authority for an ISR satellite from the National Intelligence Community level down to a theater brigade level. This would remove demand for resources that would otherwise keep tactical users from accessing the satellite for battlefield support.
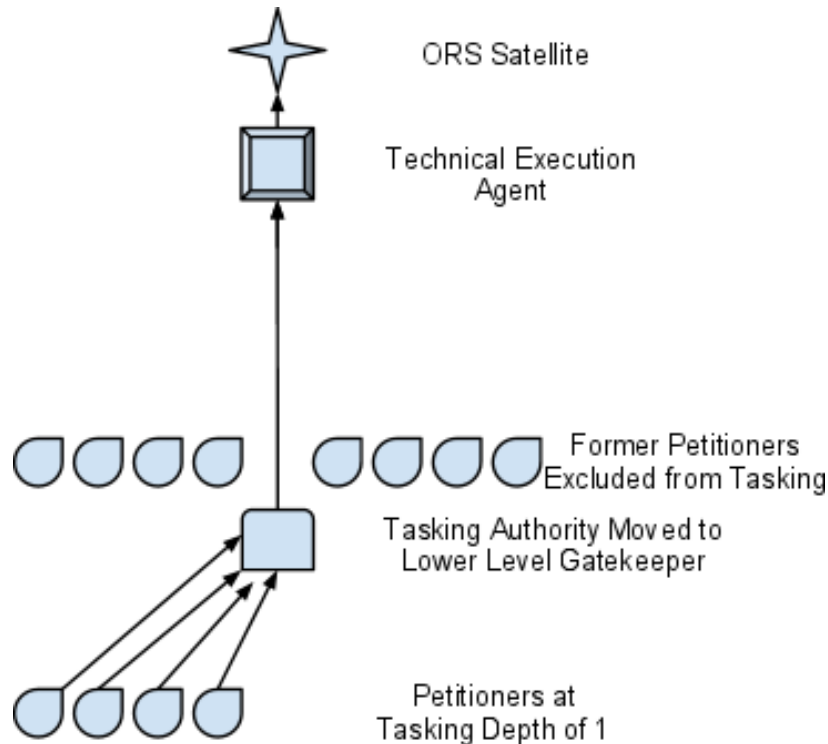
Figure 11.   Diagram Demonstrating Movement of Tasking Authority to Lower Level Gatekeeper

The decision to remove higher-level petitioners from the tasking ladder has the impact of focusing the asset upon lower level petitioners. The tradeoff here is clear: to improve the situation for the lower level petitioners, the higher-level petitioners have been deprived of the use of the asset. Such a move may seem draconian when only a single asset is considered. In a real-world situation, we assume that multiple assets are involved, each with their own tasking ladder. Within the model for a single asset, moving the tasking authority to a lower level appears to leave higher-level units totally unsupported. Factoring the assumed presence of additional assets and their associated tasking ladders reveals that the situation has multiple options for servicing all petitioners.

Another criterion for placement of the tasking authority involves expertise. As was demonstrated by the JRP experiment, expertise is necessary to successfully manage the tasking for an ISR asset. Placing the tasking authority too far down in an organization may place it at a level where the requisite expertise is not typically resident. The lack of expertise will effectively increase the gap between the knowledge level of the tasking authority and the requisite knowledge necessary to properly task the asset. This need to minimize the knowledge gap will tend to place the Tasking Authority higher in the tasking ladder where the requisite expertise to manage a collection asset is more likely to be found, unless a way can be found to push expertise to lower units, or decrease the expertise needed to effectively minimize the requisite expertise. Another argument for moving the Tasking Authority higher on the tasking ladder involves the desire to make the asset available to as many units as might be able to benefit from the capabilities it possesses. The desire to service as many units as possible comes with a price, however, which is a loss of responsiveness for individual units.

C.   TASKING COMPETITION

Inherent in all tasking situations where demand exceeds available resources is competition. The number of competitors who all seek the use of a single asset can offer insight into the likely average level of responsiveness for any individual competitor. This is a simple matter of available assets being divided up amongst the units who would like to use them. If we look at a single rung on the tasking ladder, we should be able to identify the number of units (n) who are capable of requesting tasking of the asset. This number includes gatekeepers from lower levels who are elevating a task to the current level, essentially acting as petitioners at the higher level. The chance that any single unit will have use of the asset would be represented as $\frac{1}{n}$. The issue becomes somewhat more complicated when we consider multiple rungs on the tasking ladder. In such a situation, assuming each gatekeeper offers an even chance to

their immediate petitioners, we must use basic methods for computing probability. Specifically, we must multiply the odds presented at each level a request must pass through. In this case, we seek the probability that a tasking request will be accepted and passed up the ladder at every level from its origin to the top of the ladder. We find that the likelihood of receiving tasking (and by extension responsiveness) decreases drastically with each successive step down the ladder. Specifically, the relationship can be shown as:

$$\frac{1}{n_1} \times \frac{1}{n_2} \times \frac{1}{n_2} \ldots \frac{1}{n_x}.$$

where n_x is equal to the number (n) of petitioners at the given level (x). This number quickly diminishes as the tasking depth increases. While this method may be slightly flawed in its assumption that all potential petitioners will submit requests and that they will all request the same amount, it does show the basic idea that tiered tasking systems can quickly put lower units at a great disadvantage.

To more accurately identify the decreasing odds of receiving tasking as tasking depth is increased, the triage rulesets must be included. In the basic model for ORT, is it assumed that all gatekeepers have the authority to develop and implement their own rulesets. If each gatekeeper maintains this autonomy, the importance of the tasking structure has a significant impact on the odds of a task making it to execution. If gatekeepers do not act independently, but instead adopt similar rulesets, the impact of the process structure can potentially be nullified. If the rulesets at each rung of the tasking ladder define certain tasks as high priority, they will stand a high chance of execution regardless of their positioning in the tasking ladder. The basis for such favor might be rooted in unit identity, mission type, geographic area, or other factors surrounding the tasking request. To assess the impact on responsiveness, we must examine how the various gatekeepers adopt similar rulesets.

Consider a situation in which gatekeepers at multiple levels independently agree on similar priorities for certain tasks. In such a situation, responsiveness for lower echelon units will be enhanced, at least for those particular tasks. A more problematic situation occurs when a high-level gatekeeper dictates all or part of their subordinate gatekeepers' rulesets. Unless the high-level gatekeeper is dictating rulesets specifically to favor low-level petitioners, the dictated rulesets are unlikely to benefit lower echelon units. Responsiveness for lower echelon units will be degraded. Lieutenant General Campbell clearly believes that lower echelon units are deprived of intelligence [16]. One potential cause is the development and implementation of higher echelon triage rulesets that discount the importance of lower echelon needs for intelligence. We have already theorized that the more removed a gatekeeper is from a petitioner, the more likely that supplicant tasking will occur. This suggests that filtering low echelon units through high echelon rulesets will negatively impact responsiveness. It may prove impossible for lower echelon units to receive tasking when the request conflicts with higher echelon gatekeepers' rulesets. To deliver responsiveness in such a situation, tasking authority must be moved to a level lower than the interfering rulesets.

The power of rulesets as de facto filters on tasking requests is nearly absolute. While rulesets may be devised to mandate inclusion of lower echelon requests, the dynamic nature of rulesets may render such situations temporary. Any gatekeeper between a petitioner and the tasking authority may adopt a ruleset that blocks that petitioner's requests. Moving tasking authority to lower levels on the tasking ladder can minimize the likelihood of such a blockage, increasing the responsiveness of the system for the petitioner.

To best manage responsiveness, an awareness of both tasking process structure and triage rulesets must be maintained. Given the power of rulesets, one might believe that they should be the main mechanism for managing responsiveness. When managing responsiveness using only rulesets, the different concerns of gatekeepers at various organizational and tasking levels

may heavily bias responsiveness towards the higher echelons. This coincides with the assertion that lower echelon units are deprived of intelligence support and the ability to task assets. By using adjustments to tasking process structure, specifically by managing the level of the tasking authority, it is possible to mitigate the impact of higher echelon rulesets and deliver responsiveness to units at lower echelons.

D.   TRIAGE WITH MULTIPLE MISSIONS

One potential impact of increasing tasking breadth is the potential to concentrate petitioners with different missions under a single gatekeeper. The greater the tasking breadth, the more likely this becomes. Also heightened with increased tasking breadth is the possibility for even greater disparity in the nature between the missions concentrated underneath a single gatekeeper, increasing the odds that some petitioners will be forced into Supplicant Tasking. The issue that potentially arises in such a situation is how to perform triage with multiple, disconnected missions. In the case of triage with a single mission, such as might be encountered in an emergency department where the mission is centered around fixing broken people, triage rules will arguably not be complicated by the pursuit of differing outcomes. Comparisons between like units or missions is arguably a relatively straightforward process compared to comparisons to disparate missions or units [28]. Triage may become somewhat more complicated when it is applied to multiple, non-connected missions. Rather than making a set of rules designed to improve the mission effectiveness for a single mission, the addition of multiple missions requires the introduction of methodologies to assess when one mission will benefit at the expense of another, separate mission. Lacking these methodologies, the constancy of the tasking process may suffer, bringing in an element of uncertainty that can be damaging to the overall system.

VI.   FOCUS ON THE WARFIGHTER

The ORT model offers insight into the ramifications of tasking process design choices. Such ramifications will directly impact the ability of users to leverage the tasking system to support their missions. For existing tasking systems, the ORT model can guide modification of basic aspects of a tasking structure to tailor the delivery of responsiveness. This paper had intended to discuss how modification of a tasking process structure might "focus responsiveness" upon specific units in an effort to avoid spreading asset availability across all possible units, thereby degrading responsiveness for all of them. A closer examination of the issue revealed that the idea of "focusing responsiveness" resulted in a redundancy. It became clear that, in the case of a tasking system, responsiveness and focus might be so closely linked that any attempt to separate them becomes nonsensical.

A.   FOCUS AND TRIAGE

Focus underlies the concept of triage. The most basic triage described in this paper includes three levels of priority: patients who must have immediate attention, patients who can wait for attention, and patients for whom attention will make no difference in their medical outcome. Prioritizing patients in such a fashion serves one purpose: to focus energy and resources upon those areas which will most positively impact mission accomplishment. The converse holds relevance as well: to minimize or remove energy and resources from those areas which will least positively impact the mission. Additional numbers of triage categories, or priorities, such as those being recommended by the U.S. Department of Health and Human Services for medical triage [19], do not change this situation. Instead, they increase the specificity of any adjustments to focus that may be accomplished using the triage methodology. Where ORT comes into play is identifying privileged and disadvantaged petitioners.

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Methods for identifying privileged and disadvantaged petitioners were introduced within the Petitioner Tasking model. It was shown that the arrangement of the tasking process could be modified to equalize inequities imposed by design choices. Such modifications include alterations to tasking depth, tasking breadth, and the option of implementing gatekeeper rulesets with the intent of giving advantage to specific petitioners, ostensibly based upon one or more unit traits. All of these techniques unavoidably involve engineering inequities between petitioners. Invoking the concept that responsiveness may hinge upon the ability to focus the services of assets upon specifically chosen petitioners highlights the potential that a tasking system with both privileged and disadvantaged petitioners may increase responsiveness for some, but not for all. In order for responsiveness to increase for one, it must diminish for another. Treating responsiveness as a finite resource properly frames the problem of building a responsive tasking system. Rather than searching for an artful application of tasking methodology to increase responsiveness across all petitioners, we must acknowledge that decisions must be made about which of the petitioners will receive the focus of the tasking process, and by extension, responsive support.

B.   RESPONSIVENESS AS A LIMITED RESOURCE

Responsiveness is not unbounded. It is tied to the capacity of a system. The hardware and infrastructure of an ISR system define its capacity. A poorly designed tasking process may prevent a system from performing to its capacity but even an ideal tasking process cannot push a system beyond capacity. It can maximize performance within the system's capacity. Just as the hardware and infrastructure of an ISR system limit its capacity, the capacity of a system limits the responsiveness available from the system. If the tasking system is improperly constructed, then the responsiveness of a system will suffer. This was observed at St. Joseph's emergency department. It is in the careful delivery of responsive capabilities that a tasking system can enhance the overall responsiveness of a system. It cannot increase it beyond its limits.

Revisiting the assertions of Lieutenant General Campbell, we find that his definition of responsiveness includes the ability to directly task an asset. This implies no competition and no sharing. The General wants warfighters to have the asset available for their use, without competition. This is the most responsive an asset can be from a tasking perspective: if the asset is physically available and capable, then it can be tasked. A unit will only experience this level of responsiveness in the absence of competition from others. Since responsiveness is a limited quality associated with an asset, any subdividing of the asset across multiple users will reduce the responsiveness to each of those users. An analysis of the previously presented concept of tasking depth will help explain the concept of limited responsiveness. Two tasking systems were presented, each encompassing 50 petitioners, but utilizing different distributions of the petitioners and different tasking depths. It was shown that the difference in probability of receiving service from the asset decreased dramatically as tasking depth increased. What was not highlighted was the fact that the sum of the odds for each petitioner in the process equals exactly the number of potential taskings for the asset. This must always be the case. The methodology for determining the probability is a process of successively dividing and distributing the asset's potential for tasking. All of the potential is used, as shown in Figure 12, unless specifically discarded.
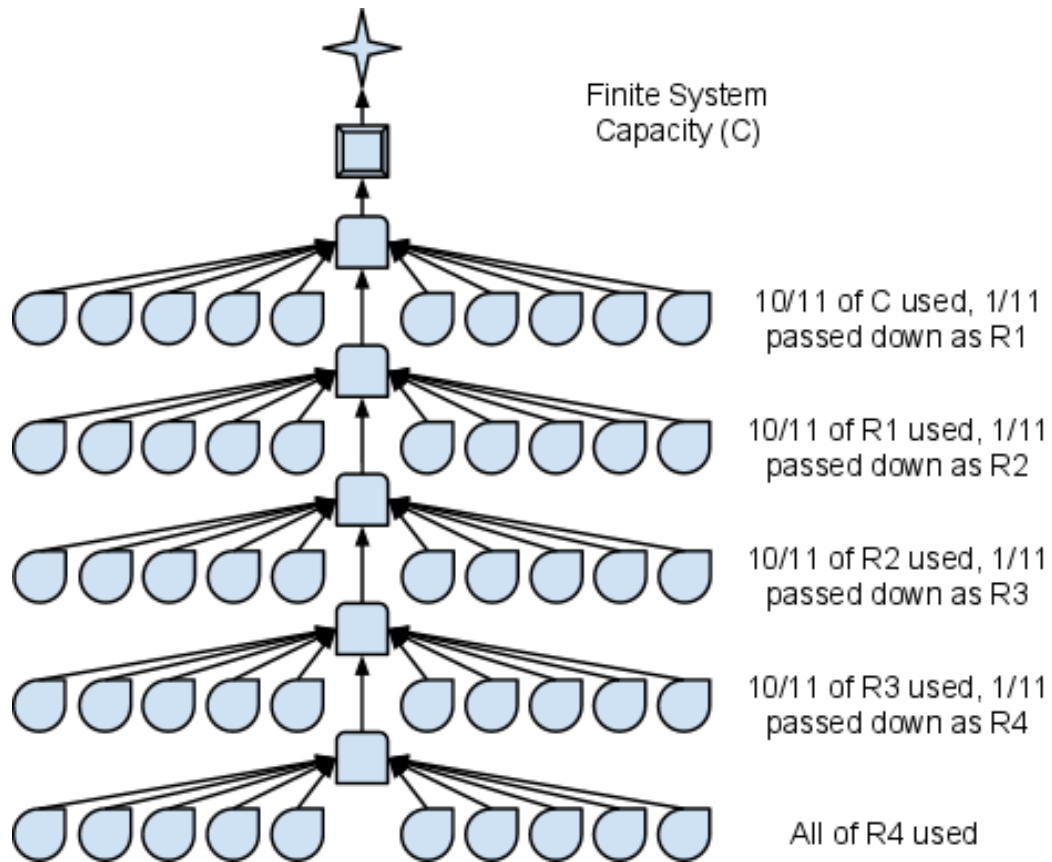
Figure 12.   Illustration of Potential Distribution of System Capacity

System capacity, designated as C in the diagram above, represents the limitations the system has on delivering services to petitioners. Attempts to increase C fall outside the realm of ORT, which deals only with methods for understanding how tasking can impact responsiveness of an overall system and its impact upon specific petitioners. Increasing capacity of the system is not a tasking issue. We have demonstrated, however, that a tasking system can be designed in such a way as to significantly limit the responsiveness of a system, regardless of capacity, much in line with the experience at St. Joseph's hospital. The key to success is identifying the best arrangement for a tasking process, and identifying where tasking authority should reside.

C.   EQUILIBRIUM

The models presented offer conditions under which tasking authority should be pushed lower on the overall tasking ladder, and conditions under which it should be elevated on the tasking ladder. Given these competing influences, it should be possible to identify an equilibrium where arguments on all sides come to impasse, a theoretical best location for tasking authority. This may not be possible without a significant amount of collection infrastructure to ensure that the required tasking of all units can be satisfied. Lieutenant General Campbell's definition of responsiveness reads in part "the ability to task an asset in real time." Unless there are adequate assets on hand to ensure that units can task when they need based upon their operational situation, it is unlikely that any positioning of tasking authority will be able to deliver the ability the General wants.

This is not a surprise, as an equilibrium point is likely to offer the best average responsiveness to users. While this has some merit, it may not meet the needs of the warfighter. We would have to alter the general's statement to read, "increased odds of being able to task an asset in real time." Arguably, if the units cannot count upon the support they need, it is unlikely that they will consider the system responsive. A more controlled approach to managing the responsiveness of ORS assets might involve focusing the responsiveness of assets upon individual units.

D.   MANAGING FOCUS

The key to delivery of responsiveness is the ability to focus responsiveness on units that require it most, whether due to their mission, geographic location, or other demographics. The basic understanding delivered by the ORT model gives multiple ways to engineer focus. Responsiveness is limited and cannot be delivered as a blanket to the entire population of potentially needy units or mission. Under this constraint, the ability to consciously target specific units, geographic areas, or missions assumes greater relevance.

Consider that the general concept for ORS includes a decision point where a need for support is established [1, p. 4] and this becomes clear. The idea that tasking for ORS assets might not carefully focus upon the issue that gave rise to the need for support clearly departs from logic. The question is not whether a tasking process should be tailorable and focused, but how best to tailor a tasking process to achieve the desired focus. This is a key impetus for the development of ORT and its supporting constructs.

If we accept the premise that concentrating, or focusing, the ability to directly access collection assets such as satellites delivers responsiveness, we must then understand how best to create and manage that focus. We have shown that the structure of a tasking process can significantly impact the responsiveness available to petitioners. We have also shown how modifications to a tasking process can alter the responsiveness of the system for specific petitioners. The measures discussed can offer options and techniques for managing the distribution of responsiveness to intelligently enhance the services rendered to specific units.

The key to focusing responsiveness lies in the willingness and ability to make decisions about which units will be singled out to receive increased access to an asset, thus increasing the odds that they will be able to task the asset when desired with little to no interference introduced by the tasking process. It must be noted that impediments to a unit's ability to task an asset that are rooted in other issues outside of the tasking process, such as hardware issues, orbital constraints, etc., are not considered a factor within ORT. The focus is exclusively upon the aspects of operations that can be controlled by modifying or otherwise adapting the processes surrounding tasking. The best a tasking process can do is to deliver the amount of responsiveness available from any given asset or system.

In order to focus responsiveness, there must be certain infrastructure components as well as organizational flexibility in the distribution of requisite technical and intelligence expertise. The crux of this issue is the gap between

resident expertise and requisite expertise to properly manage the asset at the level where tasking authority would otherwise best be positioned. One option is to deliver the expertise to that level in the form of personnel transfer. Another option is to potentially reduce the requirement for resident knowledge. As will be shown in the next chapter, VMOC has potential to become a tool to accomplish just that.

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VII. IMPLEMENTING ORT WITH VMOC

In Chapter II, it was shown that ORS is using VMOC as a tool to plug into the existing tasking processes utilized by COCOMs and JFCs. This approach is a rapid solution, but it fails to fully capitalize on VMOC's capabilities. The capabilities included in VMOC, if fully developed, promise to enable management and control of the tasking process in ways that align well with the concepts of ORT.

A. APPORTIONMENT OF ASSETS

Apportionment is among the most intriguing and powerful capabilities envisioned for VMOC. This concept involves the ability to grant users, or petitioners in the ORT model, access to direct the use of operational assets. The system includes the ability to control the specific use of the asset based upon a "control authority policy." This policy serves to establish and maintain limits on the authority of individual units [29]. Applying this ability to the ORT model, it becomes apparent that this could offer an effective method for controlling tasking depth by lowering the tasking authority to an appropriate level. This would also concentrate the use of the asset at that level, ensuring that the delivery of responsiveness was not in doubt. Units would understand the access that they have to the asset and could command it within a specified scope.

The ability to apportion assets allows the use of both reactive and proactive tasking. Either the apportionment authority can use the system in a reactive sense, awaiting requests for support and comparing them to their existing triage rulesets before apportioning the asset, or they can project the anticipated need for the assets and apportion the assets to allow units to utilize them as the need arises. The ability to use both methods arguably maximizes the utility and flexibility of the overall system.

B.   TASKING LADDER VISUALIZATION

Given the fact that VMOC is a web-based system requiring password or other authentication to enable access [30, p. 4], and as such, must track users, the opportunity exists for VMOC to build and maintain accurate depictions and statistics on the structure of the tasking ladder. Under the current approach used for VMOC, where it is plugged into existing theater tasking tools, the structure would be expected to be extremely simple with few gatekeepers or petitioners. It would still offer insight into the advantages and limitations of the structure. If VMOC were extended to lower echelon units within the command, the tools could become very illuminating.

One of the keys to understanding the tasking environment is the ability to graphically map and evaluate the overall tasking process. By producing a graphical map of the overall tasking hierarchy, users and commanders could easily evaluate the existence of potentially privileged and disadvantaged users. Such maps would allow easy assessments of tasking depth and tasking breadth. Additionally, the system could include tags on users including geographic area, missions assigned, or other demographic information to help understand how the tasking system might be biased with respect to real-world considerations.

Perhaps most importantly, the ability to visualize the tasking process can offer commanders the capability to engineer the system to focus on those units, missions, or geographic areas of greatest concern. Without the ability to clearly understand the tasking process, engineering the desired focus of assets upon specific units becomes potentially more challenging. This lack of understanding could arguably result in instances where units are inadvertently placed at a disadvantage, harming the overall mission. By offering a visualization tool, commanders can quickly and easily see how changes impact the ability of specific units to receive access to ISR assets that would most benefit their mission.

While VMOC could be modified to map out the tasking structure, it cannot do so unless access is extended to all units that may want to submit a tasking request. As was shown in Chapter I, the current use of VMOC seems to extend no further than into the highest levels of the COCOM/JFC organizational structure. To truly capitalize upon the ability of VMOC to identify and map the tasking process, VMOC must extend down to lower echelon petitioners, with intermediate gatekeepers between them and the COCOM/JFC level. Such an extension of VMOC could offer multiple benefits to units.

C.   KNOWLEDGE GAP MITIGATION

Just as VMOC might offer the capability to better understand the tasking process of an organization, it can also help units to better understand the capabilities and limitations offered by ORS assets. Such a capability is essential to narrowing the knowledge gap required to make best use of ORS assets. This is a key requirement to ensure that assets can be freely apportioned to units without concerns about their ability to properly utilize them. One option to ensure that units have the requisite knowledge to use an ORS asset involves the assignment of personnel with expertise. Such an approach is potentially expensive and time-consuming, attributes that conflict with the basic premises of ORS, which include low cost and rapid delivery of capabilities [1]. Alternatives involve identifying methods by which the need for expertise is reduced. VMOC, as the interface for users of ORS, might be engineered to help less knowledgeable users identify how best to use ORS assets, including which capabilities are appropriate for specific needs. Users of typical computers are familiar with the "Wizards" built into the software. The Wizards are carefully crafted to help users navigate some of the more technical aspects of operating or managing their computers. Such a concept might be employed within VMOC to enable less experienced units understand how best to utilize the capabilities provided by ORS assets. This is especially true in the case of proactive tasking where units are provided an asset for use and must identify the best utilization for

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that asset. Even in the case of reactive tasking, such an enhancement may be useful to units as they evaluate what type of capability they might require. One way to help deliver this is to incorporate ontologies into VMOC.

D. ONTOLOGIES

The incorporation of ontologies into VMOC may help units better understand the capabilities they are requesting and how to best match them to their collection needs. Ontologies have been proposed as a viable approach to matching ISR assets with tasks required by users [31]. Of particular interest to this approach is the possibility for ontologies to help mitigate the issue of poor communication, which may be driven by "different needs and background contexts [31, p. 2]." Such a situation may arise between petitioners and gatekeepers, especially with greater tasking breadth or in a supplicant tasking scenario. As stated in *An Ontology-Based Approach to Sensor-Mission Assignment*:

> People, organizations, and software systems need to communicate and share information, but due to different needs and background contexts, there can be widely varying viewpoints and assumptions regarding what essentially the subject matter is. The lack of shared understanding leads to poor communications between people and their organizations, severely limits systems interoperability, and reduces the potential for reuse and sharing. Ontologies aim at solving the former problems. [31, p. 2]

Definitions of ontologies vary. A useful definition is "formal models of the various elements that can be used with deductive reasoning mechanisms to produce matches that are logically sound [31, p. 1]." Figure 13 illustrates how ontologies describe the attributes of a platform. Various potential capabilities of the platform are identified. When applied to a sensor, these form a basic ontology by modeling the elements of the platform. Ontologies can be made more specific. This would be accomplished by delving deeper into the description of the

platform, identifying technical attributes that make it suitable for the tasks listed in the diagram. For the purposes of assigning sensors, the listed attributes may be entirely adequate.
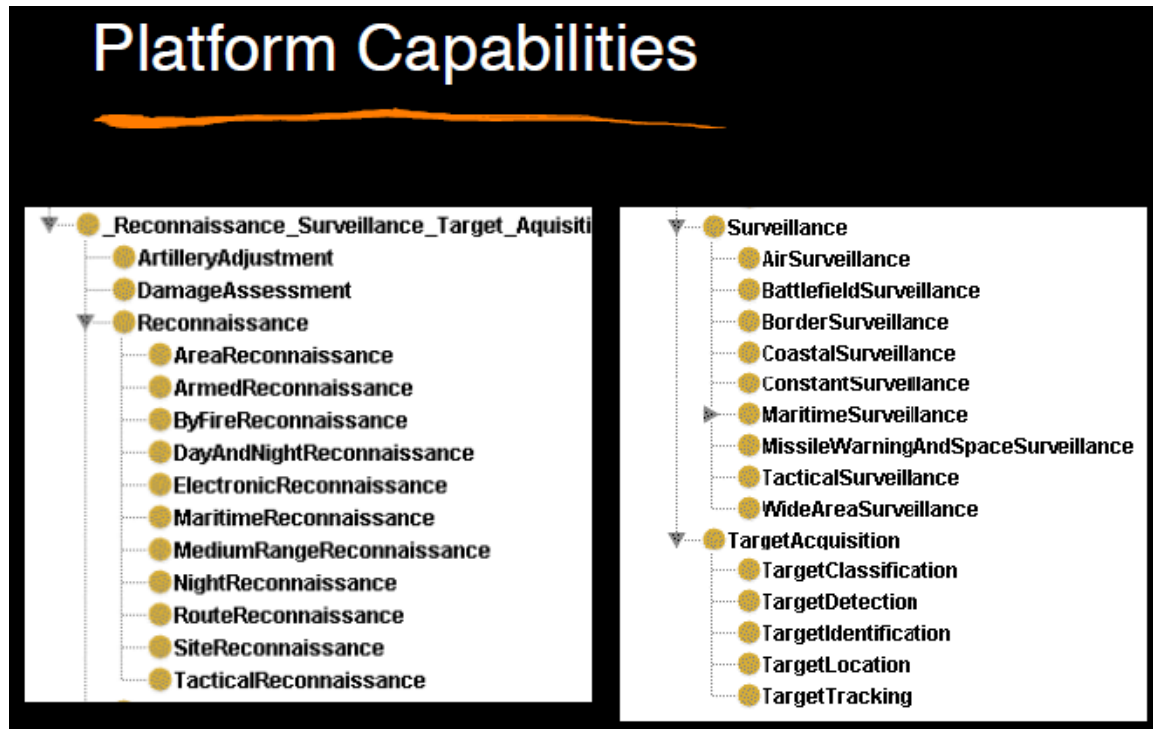

Figure 13.   Lists of Attributes Used to Build Ontologies for Sensor Platforms (From Presentation Slides for *An Ontology-Based Approach to Assigning Sensors to Tasks* [32])

An ontology's ability to identify a platform's capabilities in discrete attributes, referenced in basic language, increases shared understanding of the platform. A technical expert on the platform may prefer to discuss specific details such as frequencies, orbital altitude, field of regard, etc. These may be of little use to the warfighter who seeks to understand the utility of the platform. Such differences arise from the differing points of view of the warfighter and the technical expert. By creating an ontology to define the platform in terms usable by both the technical expert and the warfighter, a shared understanding may arise. This shared understanding can be the basis for improved communication and improved utilization of the asset. Taking this concept further, semantic

matching relations can be established and rendered graphically [31, 32]. This further simplifies communications between parties and can increase understanding of the platform. Figure 14 gives examples of simple graphical representations of semantic matching relations between a mission and candidate sensors.
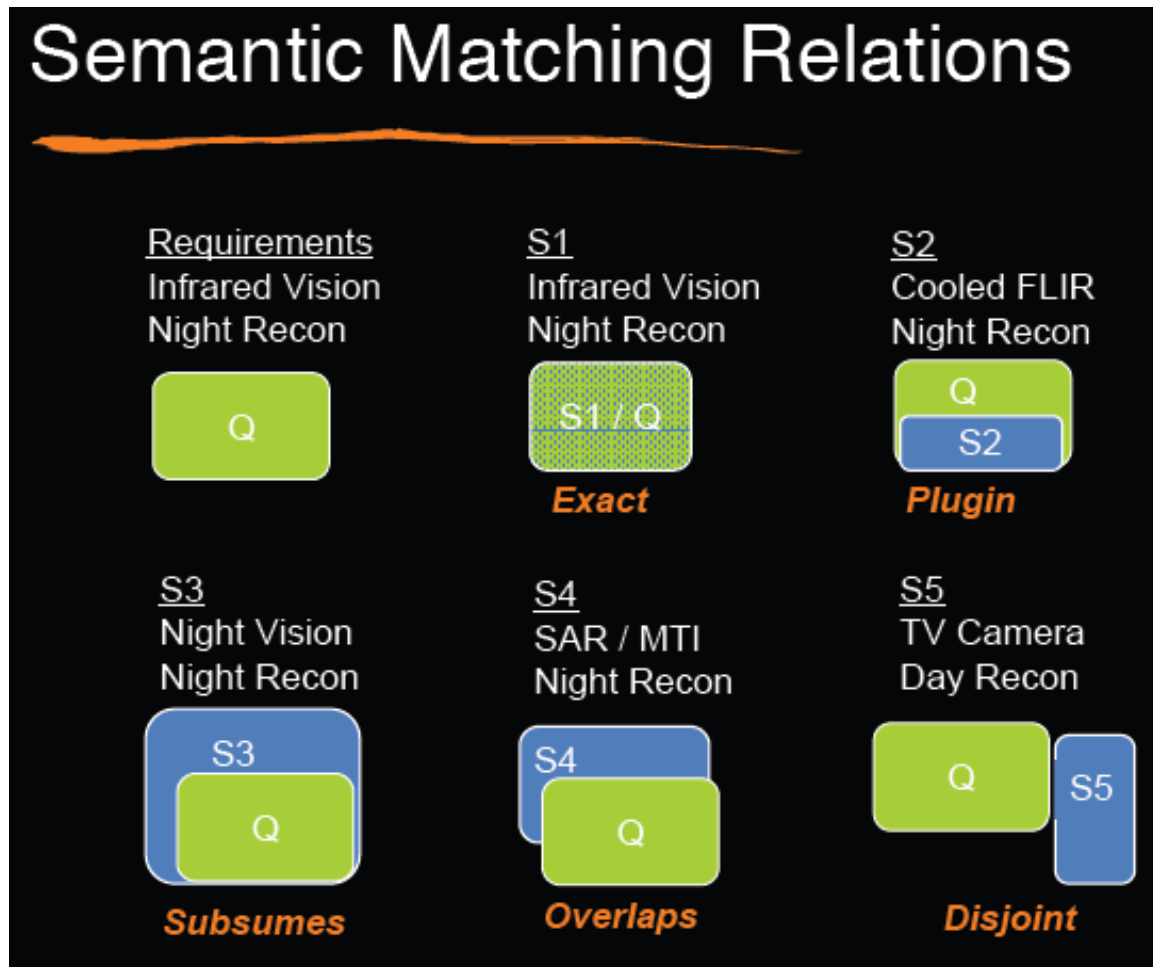

Figure 14. Graphical Representation of Semantic Matching Relations Between Sensor and Mission (From Presentation Slides for *An Ontology-Based Approach to Assigning Sensors to Tasks* [32])

The ability to graphically show the level of service that sensors can offer may reduce the expertise needed to understand their suitability for a mission. In Figure 13, S1 can be shown to exactly match the necessary requirements (Q). S5, which has a disjoint match, is easily understood to be unsuitable. S2, S3, and

S4 each have some utility for the mission, but also come with tradeoffs. S2 and S4 each partially satisfy the mission requirements. S3 and S4 meet either part of the requirements (S4) or all of the requirements (S3) but each brings capabilities in excess of the requirements. Such graphical representations can help those who might seek to use the assets but lack in-depth technical knowledge.

Ontologies may be structured in such a way that they can be programmed into computers. A good target for this is VMOC. Utilizing the textual and graphical approaches available through ontologies may allow VMOC to improve communication between petitioners and gatekeepers. By creating shared understandings of tasking requirements and options, efficiency and effectiveness of the tasking process may be improved. The ability to make ontologies machine-processable and "mediating among different people and systems" [31, p. 2] may augment the ability to push tasking authority to deeper levels without increasing the expertise resident at those levels. This is due to the ability of ontologies to generate simplified representations of complex relationships. Adding such functionality to VMOC could greatly enhance the ability of ORS to provide services to all levels of command, regardless of their resident expertise.

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VIII. CONCLUSIONS AND RECOMMENDATIONS

A.   HARDWARE FIXATION

The ORS community appears to be following historical precedent and focusing upon developing hardware and software solutions while largely ignoring potential changes to operational processes. In the case of ORS, improvements to the tasking process may have a positive impact on responsiveness. Improving hardware and infrastructure may not improve performance, as illustrated by the experience at St. Joseph's emergency department. When the department improved its processes, performance improved dramatically. Similarly, improving satellite-tasking processes may improve their ability to be responsive to the warfighter. Based upon most current unclassified information, ORS tasking improvements are largely hardware, software, and infrastructure oriented. Given the apparent dearth of study dedicated to development of basic tenets for tasking satellites, it is not surprising that established tasking processes, rather than more innovative options, are being applied to ORS. The seemingly rigid support of the community for the established National-level tasking system does not bode well for the ability of ORS to break out and develop a military-centric, focused tasking system.

B.   ISR TASKING

Satellite tasking may be described as a triage process. Such a process involves the development and application of rules to prioritize requests for collection. The prioritization is then used to assign tasks to assets. Expertise is a requirement for successful triage. The more of a gap between the expertise of the individuals involved in the process and the required knowledge, the less successful the system will be.

Expertise is not the only barrier to setting up an optimized triage system for ORS. Political pressures exist to keep the existing systems in place and apply them to ORS. Current intelligence gathering satellites are not specifically military

oriented. Instead, they serve much more than the military, and as such have many competing demands on their resources. This leads to a problem for the military, as the control of satellites may not reside within the military.

Mapping out the current National Intelligence tasking ladders as they extend to low-echelon military units may prove illuminating. We have shown that the nation's intelligence infrastructure does not specifically focus on the military, but instead is mandated to support multiple portions of the government. Competition for resources may be graphically represented using the basic ORT model. Such a depiction may also illuminate the reasons that military commanders have requested the development and implementation of ORS. Whether military or civilian, the ability of the ORT model to identify privileged and disadvantaged petitioners may offer insight into the strengths and shortcomings of the United States' overall intelligence tasking processes.

C. ORT

ORT's basic approaches to modeling and characterizing the structure of a tasking process can give insight into how organizational arrangements and process structure can impact the ability of units to receive tasking. By graphically depicting the structure of a system, it is possible to begin understanding the relationships between those who would make use of the system and those who control access to the system. Further, once those relationships are understood, the ability to identify privileged and disadvantaged users offers the ability to ensure that responsiveness is being delivered in support of the commander's objectives.

Three main characteristics of ORT were identified: tasking depth, tasking breadth, and triage rulesets. Tasking depth and tasking breadth are reflections of the structure of the tasking process. It was shown that modifications of these characteristics could greatly impact the relative ability of units to receive tasking from the system. Triage rulesets act as filters within the system by determining the priorities assigned to tasking requests. In the event that tasks encounter

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triage rulesets that assign them a very low priority, a phenomenon call supplicant tasking may occur. This represents a potential dysfunction within the tasking process and places units at great disadvantage in obtaining support. Such a situation may require modification of the tasking structure.

By modifying the relationships or structure of the overall tasking process, the commander can specifically target units with responsiveness in accordance with operational needs. In particular, the ability to grant specific units tasking authority can ensure that the units most in need of support are able to receive it. By pushing tasking authority deeper into the tasking ladder, it is possible to avoid filtering the requests of lower echelon units through the rulesets of high echelon organizations. There are limitations that can impact the ability of a commander to effectively deliver responsiveness to specific units. Most notable is the need for expertise to allow the units to make the best use of their access to the assets. In the lack of expertise, a knowledge gap may become evident that will undermine a unit's ability to make use of assets.

D.   FOCUSING RESPONSIVENESS

Responsiveness is limited. It is directly tied to the capacity of a system. Delivering responsiveness to lower echelon units is limited by the capacity of the system. It is possible to attempt to evenly distribute responsiveness across all possible units, but this appears to run counter to the desires of the warfighter as voiced by Lieutenant General Campbell. A more satisfactory solution is to focus the services of assets upon specific units or organizations, ensuring them the ability to task as necessary. Such a solution requires leadership willing to make decisions about which units will receive such services and which units will not.

E.   IMPLEMENTING ORT WITH VMOC

As a tool for tasking, VMOC possesses the potential to directly focus responsiveness upon chosen units via apportioning tasking authority to specific users. The addition of a capability to model the overall tasking process, with emphasis on the relationships between units, can deliver a powerful visualization

tool to assess which units in the process may be overly privileged or disadvantaged. Finally, the distributed nature of VMOC and its use by all units involved in the process postures it as an ideal platform to simplify an understanding of the proper use of ORS assets. By embracing the established approach of building "wizards" to help computer users through some of the more technical aspects of various programs, VMOC could close down the knowledge gap that currently poses an impediment to units who would otherwise benefit from direct access to space assets. Additionally, the incorporation of ontologies into VMOC may help further reduce the knowledge gap. Ontologies can represent the capabilities and uses for satellite assets in ways that deemphasize in-depth technical specifications. By characterizing assets in operationally relevant terms, users will have better understandings of how to request and direct collection assets.

IX. AREAS FOR FURTHER RESEARCH

In Chapter VI, the limited nature of responsiveness was presented. Spreading responsiveness equally among all possible units may not meet the warfighter's desire for baseline responsiveness for any single unit. Previous research that directly aligns with this concept has been accomplished in *Assigning Sensors to Missions with Demands* [33]. This research relates directly to sensor assignment and offers interesting mathematical approaches to understand the issues involved. Most notably, it is interested in determining a lowest level of support that will be accepted as valuable. Lesser levels of support receive "no credit for partially satisfied missions." Application of this approach to extend the ORT model may be valuable by defining the minimum service an ORS asset must give to a unit in order to be considered responsive.

A different avenue for research is contained in *A Knapsack Approach to Sensor-Mission Assignment with Uncertain Demands* [34]. The authors in this paper apply the Knapsack Problem to determine the best usage of sensors without exceeding a defined limit. Such an application may be complementary to the approach in *Assigning Sensors to Missions with Demands.* Combined, they may define the upper and lower limits for optimum petitioner service for ORS assets. They may also offer the ability to determine appropriate petitioner levels to which ORS assets might be applied. If an ORS asset has less available responsiveness than is necessary to satisfy the responsiveness needs of a target unit, it might best be focused upon a lower echelon or entirely different unit. Or it might require the combined efforts of several ORS satellites to deliver the minimum responsiveness necessary to earn the "credit" discussed in *Assigning Sensors to Missions with Demands.*

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